Indiana Bridges Historic Context Study, 1830s–1965

INDOT CC No. 050108

Report prepared for

Report prepared by

M&H Architecture, Inc.

a MEAD & HUNT **company**

February 2007

Table of Contents

Tables

Figures

Appendices

Acronyms

AASHO	American Association of State Highway Officials, predecessor to the American Association of State Highway and Transportation Officials (AASHTO)
ACHP	Advisory Council on Historic Preservation
ACI	American Concrete Institute
ASCE	American Society of Civil Engineers
BPR	Bureau of Public Roads
CCC	Civilian Conservation Corps
CWA	Civil Works Administration
DHPA	Department of Historic Preservation and Archaeology
FERA	Federal Emergency Relief Administration
FHWA	Federal Highway Administration
HERPIC	Highway Extension and Research Project for Indiana Counties
HRB	Highway Research Board
INDOT	Indiana Department of Transportation
ISHC	Indiana State Highway Commission
LTAP	Local Technical Assistance Program
NBI	National Bridge Inventory
OPR	Office of Public Roads, federal predecessor to BPR
ORI	Office of Road Inquiry
PA	Programmatic Agreement
PCI	Prestressed Concrete Institute

PRA	Public Roads Administration
PWA	Public Works Administration
ROW	Right-of-way
SHPO	State Historic Preservation Office
USDA	U.S. Department of Agriculture
WPA	Works Progress Administration, later Work Projects Administration

Executive Summary

As part of a Programmatic Agreement (PA) governing historic bridge projects in Indiana, the Indiana Department of Transportation (INDOT) is completing a statewide historic bridge inventory of publicly owned bridges constructed through 1965. Major components of the inventory project are:

- Historic context report on roadway transportation and bridge design and construction in Indiana.
- Recommendations as to which bridges are and are not eligible for listing in the National Register of Historic Places (National Register).
- Identification of historic bridges that are and are not suitable candidates for preservation.

This historic context report represents culmination of the first step in developing the statewide historic bridge inventory.

Indiana's roadways are home to more than 6,000 public bridges built before 1966. To understand the trends and events that led to their construction and the specifics of their design, this historic context report was researched and written. It is intended to provide a framework to understand the broad patterns of roadway transportation development and bridge design and construction in Indiana. The understanding that emerges from this study will shape the framing of a methodology for surveying bridges and of criteria for evaluating the National Register eligibility of bridges in the next stages of the project. To facilitate these future stages, the context study seeks to present themes relevant to understanding the significance of Indiana bridges built during the subject period.

These themes are presented chronologically and separated into two main sections, Section 2 – *Transportation in Indiana* and Section 3 – *Bridge Engineering and Construction*. Major events and trends that marked transitions in state roadway development and bridge design and construction serve to organize the contextual study. Such trends included the early twentieth-century rise in popularity of the automobile; formation of the Indiana State Highway Commission (ISHC); material and labor shortages of World War II; and introduction, adoption, and popularization of bridge materials and types.

These sections are followed by Section 4 – *Summary Discussion of National Register Areas of Significance*, which relates the broad themes presented in these sections to National Register Criteria and Areas of Significance. The report concludes with a Bibliography of sources consulted; an illustrated Glossary of Bridge Types and Terms; and an Indiana National Bridge Inventory (NBI) Preliminary Analysis of Bridge Types, which summarizes bridge types constructed in the state through 1965.

1. Introduction

A. Background

The statewide historic bridge inventory is being completed by the Indiana Department of Transportation (INDOT) as part of a Programmatic Agreement (PA) to manage and preserve Indiana's historic bridges. The PA was developed in coordination with the Federal Highway Administration (FHWA), Indiana State Historic Preservation Office (SHPO), and Advisory Council on Historic Preservation (ACHP). To assist in the development of the PA and monitor its success upon implementation, FHWA formed a Historic Bridge Task Group. The Historic Bridge Task Group includes representatives from the ACHP, Indiana SHPO, INDOT, Indiana Local Technical Assistance Program (LTAP), Historic Landmarks Foundation of Indiana, Historic Spans Task Force, Indiana Association of County Highway Engineers and Supervisors, Indiana Association of County Commissioners, and representatives from Senator Richard Lugar's Office.

The PA defines a process to identify historic bridges that are most suitable for preservation and are excellent examples of a given type of historic bridge, as well as to identify historic bridges that are not excellent examples or are not suitable candidates for preservation. This process involves three principle activities:

- Develop "Standards for Rehabilitation of Bridges on Low-Volume Roads" and include in INDOT design manual.
- Complete a statewide survey of bridges on public roads and on the public right-of-way (ROW) that were built through 1965.
- Establishes processes through which FHWA will satisfy its responsibilities under Section 106 of the National Historic Preservation Act (NHPA) for undertakings involving a historic bridge.

Attachment A of the PA sets out the scope of services for the development of the historic bridge inventory. In 2006 INDOT retained M & H Architecture, a Mead & Hunt Company, to complete Phase I components of this inventory. Phase I involves the development of the following bridge management tools:

- Historic context report for bridges in Indiana, including the development of transportation networks, to assist in the evaluation of bridges built through 1965.
- Methodology to separate bridge types into subgroups and determine data needs to evaluate individual bridges within each subgroup.
- National Register Evaluation Criteria used to determine which historic bridges are eligible for inclusion in the National Register of Historic Places (National Register).
- Historic bridge database.

Additional components of the inventory project will be completed during Phase II, including fieldwork to document and determine the National Register eligibility of historic bridges and activities to identify historic bridges that are most suitable for preservation. The completion of Phase I activities will define the approach to complete Phase II.

B. Research design and methods

This historic context report represents the first activity under Phase I. To develop the context, historians from Mead & Hunt researched statewide events and trends in roadway development and bridge design and construction, as well as national developments that affected Indiana. Research included primary and secondary sources at major repositories in Indiana, and interviews and consultation with experts on Indiana transportation history and bridge construction and design prior to 1966.

The contextual study serves to provide a framework to understand the broad patterns of roadway transportation development and bridge design and construction in Indiana. The scope of the inventory project did not include gathering research at Indiana counties or cities or investigating specific bridges. Local roadway development trends and bridge design and construction by Indiana counties and cities may represent important local themes. Such local developments are expected to be investigated during future data collection efforts focused on specific bridges.

During the current project phase, research was conducted at INDOT, Indiana SHPO, the Indiana State Archives, Indiana State Library, and Indiana Historical Society Library in Indianapolis. Additional research was conducted at the University of Wisconsin's Wendt Engineering Library (for national journals), and the Wisconsin Historical Society in Madison, Wisconsin (for its collection on U.S. history). Dr. James L. Cooper, Professor Emeritus of History of DePauw University and author of two major works on Indiana's pre-World War II bridges, served as technical advisor and provided assistance in the development of the contextual study and oral history interviews.

Key sources for the contextual study included the following:

- Annual reports of the ISHC.
- Historic maps of the state showing transportation development, especially the 1876 Illustrated Historical Atlas of the State of Indiana and the state highway map of 1919.
- State and national engineering journals from the period.
- Oral history interviews with bridge engineers and transportation historians who worked with Indiana bridge construction or design prior to 1966.
- National Register nominations for individual bridges.
- INDOT's bridge inventory databases.

- Indiana SHPO's historic bridge database.

- Dr. Cooper's books, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930* (1987) and *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942* (1997).

- George E. Gould's book, *Indiana Covered Bridges Thru the Years* (1977).

These and other sources consulted are provided in the Bibliography. Photographs of individual bridges included in this historic context study are derived from previous information gathered by LTAP and provided to Mead & Hunt by INDOT.

The inventory project includes bridges located on public roads and on the public ROW constructed through 1965. Railroad bridges, privately owned bridges, bridges for which INDOT does not have primary maintenance responsibility (select border bridges and bridges maintained by other state and federal agencies), and bridges located on interstate highways are not included in the inventory project. As such, the contextual study only provides limited discussion on themes related to non-roadway and private structures.

The Indiana National Bridge Inventory (NBI) Preliminary Analysis of Bridge Types (Appendix B) was derived from county and state databases provided by INDOT. Mead & Hunt combined these databases and ran queries to identify bridges built through 1965. The analysis provides general characteristics of bridge types built during the subject period. Through this analysis, Mead & Hunt identified that there may be certain errors in assignment of bridge types and dates of construction that are expected to be resolved as the project progresses. At such time, the database will be corrected and the analysis of bridge types adjusted. During the course of the inventory project, the total number of bridges and their classification by type may increase or decrease based on newly identified information. Currently, the combined database includes 6,333 structures on Indiana's public roads and on the public ROW constructed through 1965. This number excludes bridges for which INDOT does not have primary maintenance responsibility, privately owned bridges, railroad bridges, and interstate highway bridges.

Mead & Hunt would like to thank the following federal and state organizations and individuals for assisting us with this study: Federal Highway Administration (FHWA); Indiana Department of Transportation (INDOT); Indiana Department of Historic Preservation and Archaeology (DHPA); Robert Bettge; William Guyer; Warren T. Hobson; John Samuelson; Steve Weintraut; and Dr. James L. Cooper.

C. Purpose

The purpose of the statewide bridge inventory is to assist in compliance with major federal preservation laws and regulations that affect the management of historic bridges. These laws and regulations include the NHPA of 1966 and the U.S. Department of Transportation Act of 1966.

The NHPA of 1966 established a national policy for the protection of historic properties and archaeological sites, and outlined responsibilities for federal and state governments to preserve our nation's heritage. The NHPA created the National Register, which is an official list of sites, districts, buildings, structures, and objects of national, regional, or local significance. To qualify for the National Register, a property must be associated with a significant theme, and it must retain the characteristics that make it a good representative of properties associated with the past. The National Park Service within the Department of the Interior is charged with maintaining the National Register. Historic bridges are among the structures listed in, or eligible for listing in, the National Register.

Historic bridges may be afforded protection under NHPA and transportation regulations, which require agencies to take into account the effect of projects on historic properties. Section 106 of the NHPA requires federal agencies and owners seeking federal assistance to review actions which may affect a property listed in, or eligible for, the National Register. The process includes identifying historic properties, assessing the effect of proposed actions on historic properties, and developing agreements that specify measures to deal with any adverse affects. To comply with Section 106, appropriate consultation among the federal agency, the SHPO, Native American tribes, the public, and other interested parties is required. The ACHP, an independent federal agency in the executive branch, oversees the Section 106 review process.

The U.S. Department of Transportation Act of 1966 created the Department of Transportation, whose role was to coordinate transportation programs and facilitate the development of coordinated transportation programs. Section 4(f) of the Act, (as set forth in Title 49, United States Code (USC), Section 1653(f) and later codified in 49 USC Section 303), applies to undertakings that require the “use” of a historic property, including a bridge. Under Section 4(f), a historic property is any property listed in, or eligible for listing in, the National Register, or a historic property that is locally designated or recognized. The federal agency must ensure that the provisions of Section 4(f) are met before approving a federally funded project. Projects, including appropriate rehabilitation, that do not impair the historic integrity of a bridge are not subject to Section 4(f)

The purpose of this historic context report, the first component of the statewide bridge inventory, is to identify and describe the trends and events that were significant in roadway transportation and bridge design and construction in Indiana through 1965. The historic context will assist in understanding how bridges may qualify for listing in the National Register. This report represents the culmination of gathering historical research, conducting oral history interviews, and synthesizing this information to identify themes relevant to Indiana’s bridges and its roadway transportation system during the subject period. Examples of bridges are given in the context to illuminate relevant themes; the status of these bridges will be confirmed during future project tasks. Additional project tasks including field survey and bridge-specific research will further inform these efforts and the understanding of the state’s transportation networks and bridge construction programs presented in the historic context.

The purpose of the report is to define the relevant historic contexts that will be used to assess National Register significance and establish periods of significance for bridge types built in Indiana through 1965. The significant themes identified in the historic context report will inform subsequent steps of the inventory project. Specifically, the historic context report identifies themes that are expected to relate to the National Register significance of bridges constructed in Indiana through 1965. To that end, the contextual study concludes with a review of the National Register Areas of Significance that may be applicable. This serves as a starting point for the future development of National Register criteria for Evaluation specific to Indiana's bridges during the next stages of the inventory project. Based on the scope of research conducted to complete the contextual study, National Register criteria are expected to focus on the state level, but will also accommodate significant local trends and developments identified through future research.

2. Transportation in Indiana

A. Roads and canals (1816-1850s)

Indiana became a state in 1816 with a population largely comprised of settlers of western European descent and Native Americans. Indiana's population had doubled in the 1820s and nearly doubled again in the 1830s, with most of the growth in the southern portion of the state. The state was well suited for agricultural ventures and settlement was encouraged by federal land sales at affordable prices. Indiana's location, west of the Appalachian Mountains, resulted in its relative isolation from eastern markets and reliance on the Ohio and Wabash Rivers. Until the arrival of east-west railroad connections in the 1850s, the Ohio-Mississippi River to the south was Indiana's most important route for commerce. Because of their location, the Ohio and Wabash Rivers concentrated early settlement in the southern half of the state around the borders with Ohio, Kentucky, and Illinois.[1]

Transportation development in Indiana during the first half of the nineteenth century focused on the development of canals and roads to direct trade from the settled areas of the state to the Ohio River, Wabash River, and their main tributaries. Major communities that had developed in the state by 1850 included Madison, New Albany, Lafayette, Richmond, Jeffersonville, Terre Haute, Vincennes, and Evansville, all of which were located on waterways.[2] The state capital was first established at Corydon, in Harrison County, in the far southern part of the state, but moved to Indianapolis in the 1820s.[3] However, Indianapolis did not emerge as a large urban entity until the development of the railroads later in the century.

Major transportation improvements were seen as essential to continue the growth and prosperity of the state's economy, by providing access to markets and lowering the costs of exports and imports. In response, the legislature enacted the Internal Improvements System of 1836 to fund, plan, and construct a network of canals, railroads, and turnpikes. Engineering surveys completed in 1835 recommended and prioritized the types of transportation facilities to be funded under the system. Canals, railroads, and turnpikes were to be given priority and little attention was given to public roadways beyond those already established. The System of 1836 was funded through long-term loans to be paid off with the revenue generated from tolls.[4]

After construction commenced on projects in 1836, expenses proved greater than revenues and the state suffered financial strains attempting to service the debt. Taken together with the national economic slowdown of the late 1830s, the program became bankrupt and was abandoned in 1842. The remaining projects, including canals, turnpikes, railroads, and public roads, were offered to private companies and local units of government.[5] The massive financial problems suffered by the state in its attempts to finance large transportation projects through borrowing led to a provision disallowing state debt in the Constitution of 1851, which superseded the original Constitution of 1816.[6] The provision against borrowing remains in effect today.

The construction of the Wabash and Erie Canal, the Michigan Road, and the National Road were important interstate transportation routes in the first half of the nineteenth century that linked settled areas to previously isolated areas of the state, while local roads connected settlers with towns, mills, churches, and schools.[7] Transportation in the second half of the nineteenth century was dominated by the growth of railroads and privately financed turnpikes. By the end of the century Indiana, like other states, experienced the rise of urban centers and industrialization.

(1) Early roads

Early long-distance roads commonly developed along established overland routes and traces that had been used by Native Americans or as seasonal migratory routes for buffalo that followed the advantages offered by the terrain. Examples include the Cedar Lake Trail from Chicago to Vincennes and the Old Sauk Trail from Detroit to Chicago (later this route formed portions of the Lincoln Highway).[8] Other early roads included the Vistula Road, which united with the Old Sauk Trail near South Bend and formed a link between Chicago and Toledo. Extending east, Wayne Trace connected Fort Wayne to Fort Recovery, Ohio (this route roughly follows U.S. 33). The Quaker Trace followed the Ohio border north of Richmond to Fort Wayne. The Buffalo Trace crossed the southwestern portion of the state from New Albany to Vincennes. These roads were concentrated in the counties adjacent to Lake Michigan in the north and along the waterways that border the state in the south.[9]

The development and maintenance of local roads were largely the responsibility of township and county officials. The primitive roads (unpaved) were used by horses, oxen, wagons, and foot traffic. Some were merely paths cut through woodland, with stumps remaining in the “roadway.” Shortly after statehood, state legislation provided for local road and bridge improvements by giving county commissioners the responsibility to open, relocate, maintain, and vacate county public roads. It allowed counties to appoint road supervisors and levy taxes to construct and maintain county roads. Physical labor on roads by local eligible male citizens could be substituted for payment of the road tax. Counties were able to generate modest funds for local road improvements through property taxes.[10]

State transportation improvements were funded with three percent of money received from federal government sales of land to new settlers. Roads constructed with these funds were called “Three Per Cent Roads” or state roads. During the 1820s, the state legislature completed surveys to build a system of roads to link the state’s new capital of Indianapolis to other major settlements in the state. In 1821 there were 22 state roads and the greater percentage of mileage was in the southeastern portion of the state. By 1831 about 50 state roads connected major communities; however, these roads still included few improvements and typically had dirt surfaces.[11]

In the 1830s two roads were constructed across Indiana that provided access to the central and northern portions of the state from the settled areas to the south and east. The Michigan Road and the National Road quickly developed into main overland arteries that traveled east-west and north-south, respectively, to facilitate settlement, carry goods to market, and help establish new communities. This is especially true of the important east-west National Road, which opened Indiana to the Atlantic seaboard. These roads account for the major road projects undertaken with assistance by the state of Indiana (Michigan Road) and the federal government (National Road).

The earliest known masonry and covered truss bridges constructed in the state were built on the Michigan and National Roads.[12]

Legislation in the 1840s gave further authority over roadways to county commissioners as they were now authorized to establish road districts and to erect bridges over waterways for public access. Improvements were to be financed by donations, subscriptions, and local road taxes. Although this legislation encouraged transportation improvements, local taxes were not popular so funds were scarce. The lack of public funding led to an increased number of private ventures that completed road improvements and operated toll roads.[13]

(a) Michigan Road

Shortly after statehood, plans to establish a north-south military road to connect Lake Michigan to the Ohio River at Madison commenced. The federal government assisted in this effort by negotiating a treaty with Native American tribes to obtain ROW of 100 feet for a road corridor and by providing funding generated from the sale of federal land to new settlers. The state provided additional funds to survey the 264-mile route and to cover the costs for road and bridge construction.[14]

In 1828 a state commission was established to oversee planning and construction of the route. Intense rivalry between communities wishing to be located along the route ensued, which delayed efforts to begin construction. In 1830 the Indiana legislature established the route from Madison, via Versailles, Napoleon, Greensburg, Shelbyville, Indianapolis, Logansport, South Bend, and ending at the harbor at Michigan City. Construction of the Michigan Road commenced in 1830 at the Ohio River, at Madison, and worked north. After its completion in 1837, the state was unable to fund its maintenance and the road was turned over to local authorities.[15]

(b) National Road (Cumberland Road)

The National Road, also called the Cumberland Road, was begun in Cumberland, Maryland, in 1811, by the federal government. By 1818 the roadway reached the Ohio River in Wheeling, Virginia, and work continued across Ohio toward Indiana. By the late 1820s efforts to extend the road across Indiana from the Ohio border commenced. The road was to be constructed 80 feet in width and follow a line connecting Richmond in the east, through Indianapolis, to Terre Haute in the west, for an approximate distance of 150 miles in Indiana.[16]

Between 1829 and 1838 Congress provided the funding for clearing the route of trees, grading and surfacing the road with stone and gravel, and erecting culverts and bridges of stone.[17] Construction started at Indianapolis and extended to the east and west to the state borders. Some of the earliest recorded bridge construction in the state occurred along the National Road.[18] National Road bridge construction in the 1830s included covered wood truss bridges over the East Fork of the Whitewater River at Richmond and the West Fork of White River at Indianapolis.[19] Bridges along the route were frequently covered wood truss bridges, accommodating one or two lanes of wagon traffic.[20] After its completion in 1838, the federal government turned over the National Road to the state, which in turn gave control of sections of the road to counties and private toll companies.[21]

The road was heavily used in the years immediately following its construction and its heyday of use occurred during the 1840s. Ensuing competition by railroads resulted in decreased use; however, the road continued to provide important regional and local access. The National Road was one of the few federal road projects undertaken in the 1800s and is recognized as an important public works project at the national and state level. It was the only interstate roadway planned and constructed by the federal government before the 1940s. Current U.S. 40 largely follows the route of the National Road.

The construction of state and local roads and toll roads continued during the mid-to-late nineteenth century to serve local economic needs and to connect communities together. The extensive road system that emerged is evident in the 1876 *Illustrated Historical Atlas of the State of Indiana*, which shows that roads had been established in each county of the state.[22]

(c) Turnpikes and plank roads

In the absence of an adequate number of improved public roads, private ventures were chartered to construct toll roads, or turnpikes. These roads also aided settlement and agricultural production of many regions of the state. Farmers who drove animals and hauled crops by wagon along the road were the most frequent users of turnpikes. These improved roadways were often macadamized, built of clay, or of wood planks and often included a graded ROW and bridges.[23]

The Indiana legislature chartered companies to construct turnpikes in the 1820s and also under the Internal Improvement System of 1836.[24] Examples include the Madison and Napoleon Turnpike Company chartered to construct a turnpike between these two cities.[25] Pendleton Pike, which traveled from Indianapolis, to Pendleton, to Muncie, was an early turnpike which is roughly followed today by SR 67.[26]

Plank roads were also constructed as private ventures. Timber was readily accessible and less costly than stone, macadam, or clay. In Indiana, the construction of plank roads began in 1845. Dubbed the “farmer’s railroad,” plank roads allowed wagons to convey greater loads than dirt roads could accommodate.[27] By 1849 there were plank roads at Fort Wayne and Indianapolis. Current SR 3 follows the route of a former plank road that extended from Fort Wayne to Bluffton.[28] Poor construction made continued maintenance of plank roads costly as the wood rotted in less than 15 years.[29] By 1860 many plank roads in the state had been abandoned, due to competition by the railroads.[30]

(2) Canals

The largest state transportation project – and among the largest canals constructed in the country – was the Wabash and Erie Canal. With the completion of the Erie Canal in 1825, interest in constructing a canal linking Indiana to New York City via the Erie Canal increased. In 1827 Congress offered Indiana federal land grants to aid in funding the construction of the canal.[31]

Work began on the canal in 1832, and a segment connecting Lake Erie to Lafayette was opened in 1843. The canal extended south to Terre Haute in 1849 and to Evansville in 1853.[32] The cost of construction and maintenance was higher than expected and decreased toll revenues from competition by railroads resulted in increasing losses. At the same time, the state was experiencing financial strains from other projects in the System of 1836. As a result, the state transferred portions of the canal to local units of government and private ventures. As canal use declined, portions fell into disrepair or were abandoned by 1874.[33]

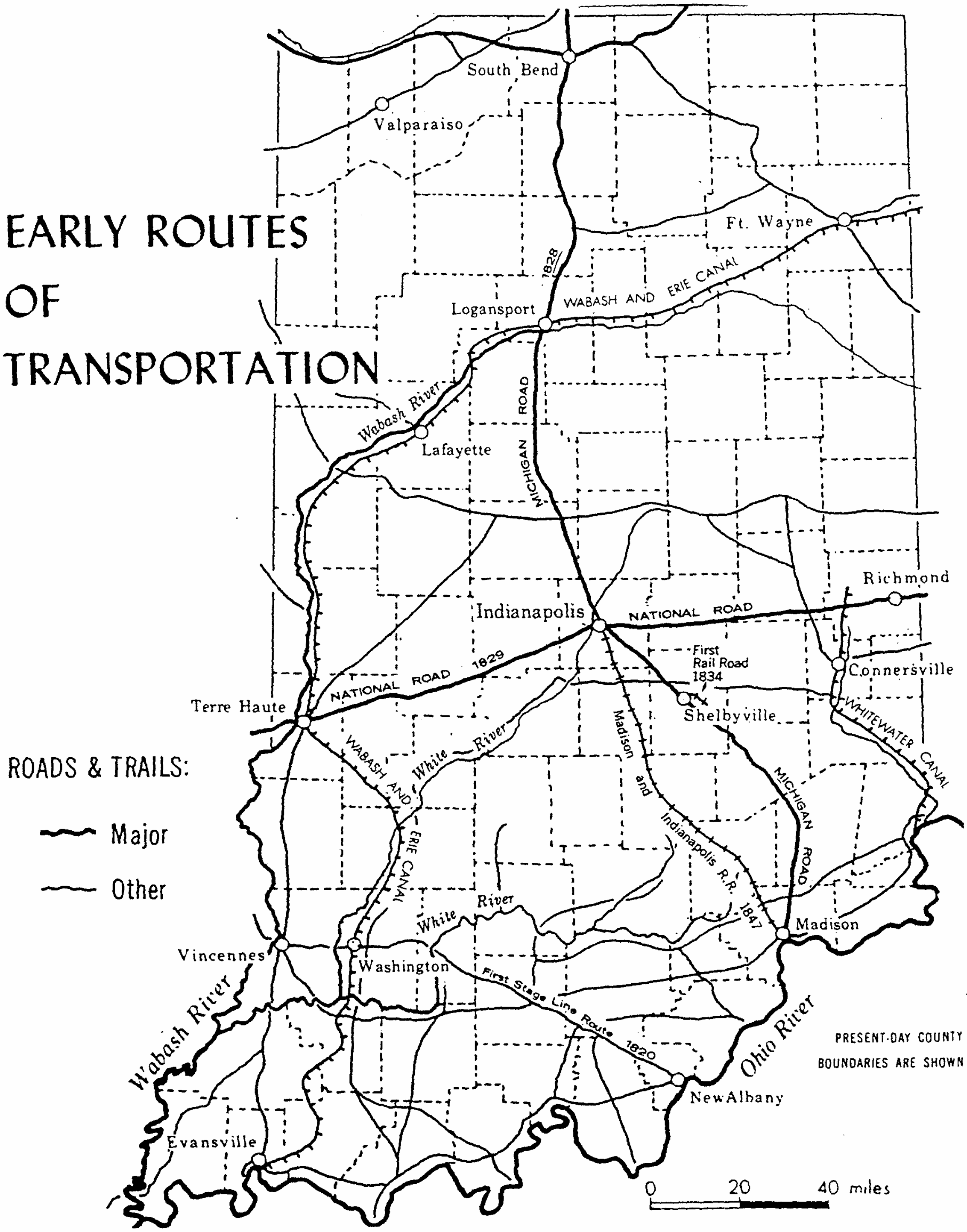
Other major canal efforts in the state included the Whitewater and the Central Canals. Work began on the Whitewater Canal in eastern Indiana from the Ohio border in 1836. The canal extended south from Cincinnati, Ohio, and connected Brookville and Hagerstown in the north in an effort to facilitate trade south. Only a small portion of the Central Canal was completed in Indianapolis. These efforts at canal building were largely unsuccessful due to the collapse of the System of 1836 and the subsequent competition from the railroads.[34] Both canals fell into disuse by 1865 for navigation, although the Central Canal is still used in part for water supply and recreation in Indianapolis.[35] See Figure 1 map showing early transportation routes.

B. Railroads (1850s-1910s)

Railroads were first chartered by the state in 1830-31 and sporadic railroad construction followed in the 1830s and 1840s. Indiana's first substantial line was completed in 1847 between Indianapolis and Madison. A transportation revolution was soon in progress—a "railroad mania" according to some historians—and within 30 years the state had a rail network of over 4,000 miles. Compared to canals, railroads were easier and faster to build, could go almost anywhere, offered year-round service, and generally provided such powerful competition that the financially troubled canal era was soon over. Plank roads, envisioned by some in the 1840s as competition to railroads, quickly suffered the same fate and were largely abandoned by 1860.[36]

Following the settlement and transportation pattern established in the decades after statehood, the early railroads were intended to serve the waterways and southern Indiana, as well as the capital in the center of the state. The Madison-Indianapolis line was instrumental in establishing Indianapolis as a central rail hub and the largest city in the state. The line's success sparked interest in the development of other lines. Initial railroad construction was largely on north-south routes, but soon east-west routes were constructed, linking to markets in the East and increasing development in central and northern Indiana. At the same time, shorter lines were built between Indiana cities to give farmers easier access to nearby markets.[37]

In 1880 five major railroads crossed Indiana to reach Chicago from the east, establishing a pattern later to be followed by state and national highway systems. The first large integrated rail system in Indiana was established by the Pennsylvania Railroad in the 1880s and 1890s. It was followed by the even more extensive New York Central. These lines are significant as indicators of the growing industrialization and urbanization in the nation and in Indiana. Urban centers that developed as rail centers included Fort Wayne, Logansport, Lafayette, Terre Haute, and particularly Indianapolis.[38]



Source: Robert Kingsbury, An Atlas of Indiana (Bloomington: Indiana University Foundation, 1970), 74.

Figure 1. Early routes of transportation

With the expansion of urban centers came the electric railway in the 1880s and 1890s. In different forms, electric railways served both city centers, as street railways, and routes between cities, as the interurbans. Almost all the interurban lines connected with Indianapolis, reflecting the centralized urban role the capital city played in the state.[39] The electric railway offered a more flexible and lighter-weight, self-propelled vehicle than the large steam locomotives that required an extensive infrastructure for fuel and water. Within cities, small streetcars could readily navigate the city street grid using electric power provided by a central generating source. Streetcars and interurban electric cars were still heavier than horse-drawn wagons, however, and necessitated increased load-bearing capacity in bridges on streetcar routes.

C. Roads (1850s-1910s)

Following the financial disaster with state bond-financed internal improvements of the 1830s and 1840s, turnpikes were turned over to private companies that operated them as toll roads. This included sections of National Road. Legislation in 1852 empowered private companies to locate and build macadamized or gravel roads. Unlike the state, private companies could borrow funds through bonds or other loans to finance the work, and could begin charging tolls as soon as 3 miles were completed. Soon after the expansion of toll roads, however, the legislature initiated tax-supported private roads that would be free and competitive with the private toll-roads. In 1877 counties were authorized to construct roads with taxes on roadside property.[40]

The *Illustrated Historical Atlas of the State of Indiana*, published in 1876, depicts the nature of the state's road and rail transportation which was greatly expanded by this time. Cities are served by rail lines that connect with other cities and some smaller towns. As illustrated by transportation links surrounding Indianapolis in Marion County, a few intercity roads parallel rail lines, such as National Road, Oakland Toll Pike, and Brookville Road. Figures 2 and 3 show representative portions of the 1876 atlas. Local roads outside the city follow section lines and connect individual farms with other farms, mills, churches, and railroad depots. In the pre-automobile era, when local travel was by horse and horse-drawn vehicle, local roads connected destinations that could be reached largely within a day, often including the return trip. Longer trips would typically be completed via the railroad.[41]

Advances in paving

Advances in stone surfacing by Thomas Telford and John McAdam, in England, led to the emergence of better road building and surfacing. Telford introduced meticulously shaped blocks of stone with angular edges that fit together closely, thus distributing the pressure of traffic more equally. These larger blocks were surfaced with a smaller layer of stones to increase smoothness. John McAdam, working in England in the 1810s, demonstrated successfully that a carefully built layer of small broken stones could effectively handle traffic loads. McAdam's broken stones would compact into an interlocking mass that did not deteriorate as rapidly as smooth stones or gravel. McAdam or "macadam" paving increased road reliability and was likely first used in cities in the 1830s on section of the National Road in Indianapolis.

M. G. Lay, *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them* (New Brunswick, N.J.: Rutgers University Press, [1992]), 73-77; *The National Road: Maryland, Pennsylvania, West Virginia, Ohio, Indiana, Illinois* ([Washington, D.C.]: United States Department of the Interior, Southwestern Pennsylvania Heritage Preservation Commission, National Park Service, 1994), 8-9.

For horse-drawn travel through the 1880s and early 1890s, a simple gravel-surfaced road would be considered an improved surface, compared to a dirt road that may or may not be graded. The optimal improvement would involve the use of a macadamized, or crushed and rolled gravel, surface. The fact that an unimproved road was considered adequate is suggested by the fact that farmers, whose horse-drawn wagons used the local roads, resisted paying taxes for gravel or macadam improvements and thus seemed content with dirt roads. A demand for improved roads emerged with the advent of the bicycle in the 1890s, fostering a new constituency for better roads. This difference between the needs of farmers and the needs of cyclists is reflected in the fact that in 1892 the Commercial Club of Indianapolis, an urban group, lobbied for improved roads, but the State Board of Agriculture, representing farmers, supported only minor reforms. The legislature compromised by authorizing better roads upon the petition of county residents.[42] Within a decade the situation would be changed forever with the introduction of the automobile.

D. Urbanization (1890s-1910s)

The decades after 1880, as reflected in the expansion of railroad hubs and the growth of interurban and streetcar electric railway systems, were a time of population shift in Indiana. While the first half of the nineteenth century had seen population and transportation focused in the rural, southern parts of the state, the second half saw increasing shifts to the northern counties and to the cities. Exploitation of natural resources, expansion of transportation networks, and large-scale manufacturing contributed to this shift. Indianapolis passed the 100,000-population mark in 1890, the only city to do so by 1920, largely due to its central location as a transportation hub. The other city to experience spectacular growth was Gary, the city built by United States Steel in Lake County, east of Chicago. Established in 1906, its population was 55,000 in 1920.[43]

The expansion of cities brought the introduction of new urban systems, such as streetcar transportation networks noted above. Other urban necessities included utilities, such as gas, water, electric, and sanitary systems, and urban amenities, such as parks and boulevards with accompanying bridges.[44] Expanding downtowns needed new and larger buildings, sending architects and engineers in search of taller office buildings, resulting in the development of the skyscraper. The new architectural forms celebrated the city and its buildings and worked to counter a long-standing impression of the city as an unhealthy, dangerous, poverty-ridden environment, in contrast to the presumed open and healthy rural environment.

Among the most vibrant and energetic of the new urban centers was nearby Chicago. In 1893 Chicago hosted the World Columbian Exposition, which set forth a vision of the new city with such power that it influenced urban design and planning for years. Because of its celebratory aesthetic it became known as the “City Beautiful.” The term “City Beautiful” was coined by Charles Mulford Robinson. Robinson was a journalist who wrote about the exposition, then later became a planner and wrote *Modern Civic Art, or the City Made Beautiful* in 1903.[45] The design of the site was planned largely by architect and planner Daniel H. Burnham and landscape architect Fredrick Law Olmsted. The development of Portland cement earlier in the century, and its widespread availability in United States by 1890, led to extensive suggestions of its uses at the exposition to create concrete buildings and structures influenced by classical Greek and Roman stone architecture. At the exposition, the buildings employed plaster to suggest the many architectural and ornamental possibilities of concrete, resulting in its being called the

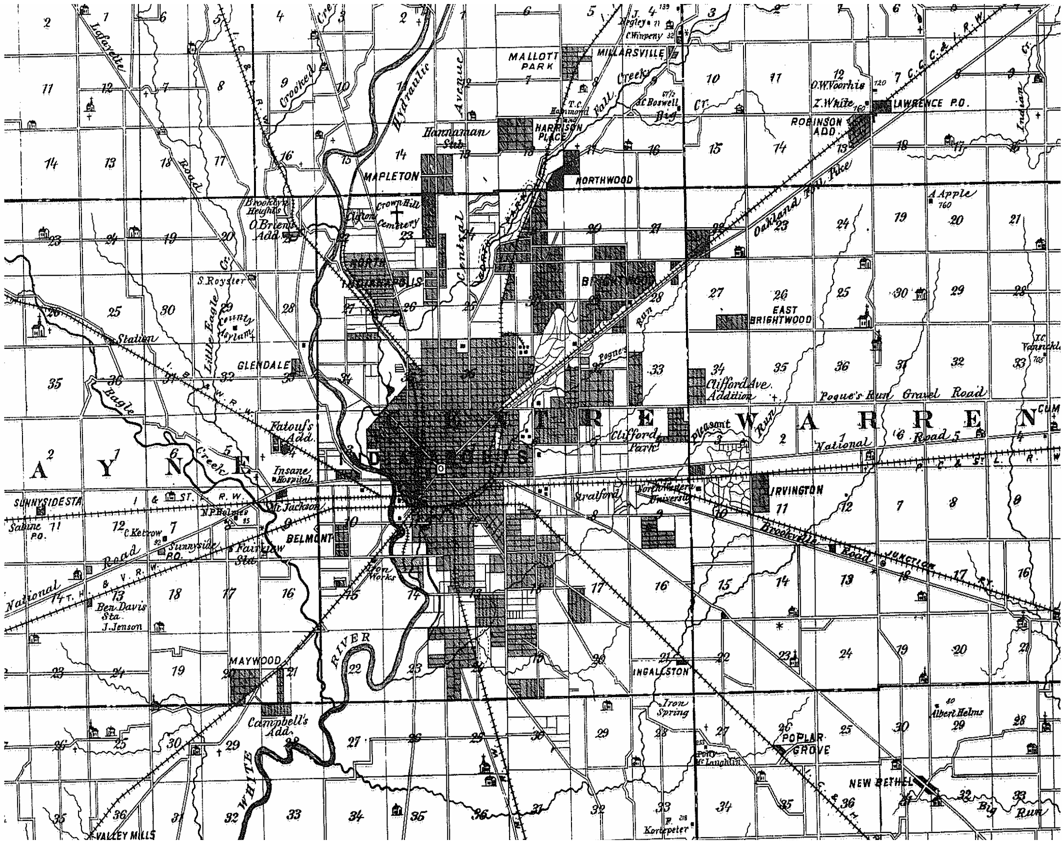


***Figure 2*.** Marion County in 1876

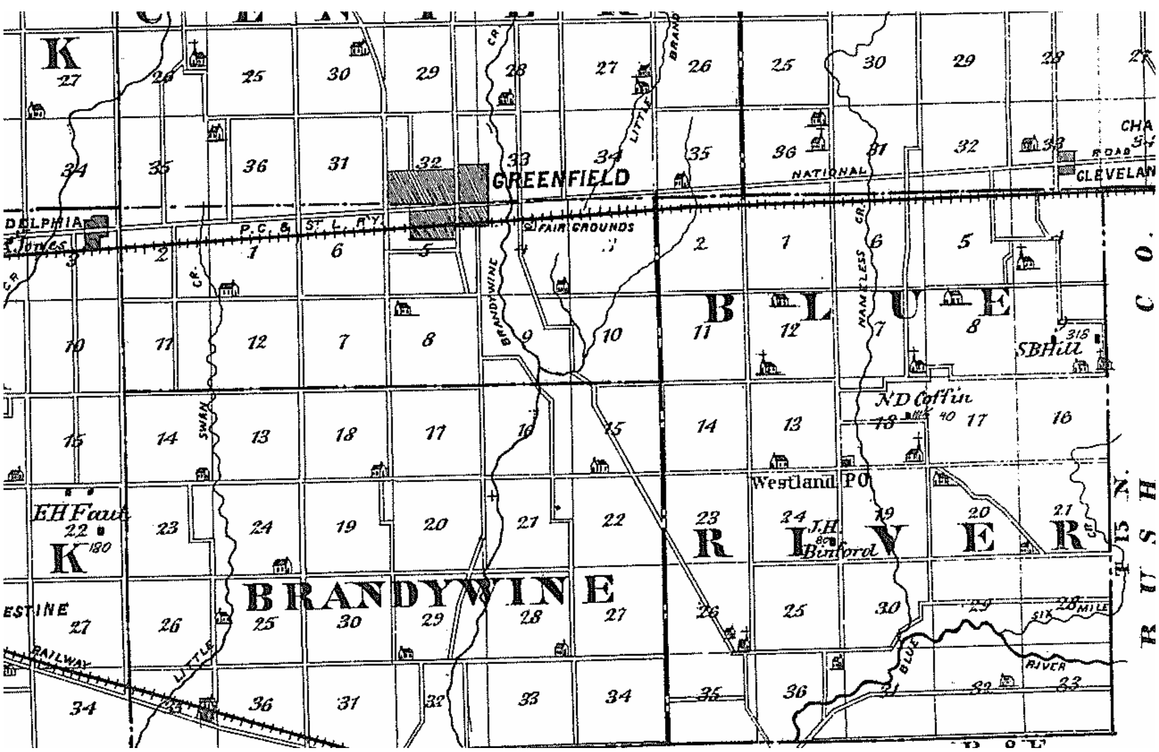


***Figure 3*.** Map of Southeast Hancock County from 1876 atlas

"White City." In addition to being less expensive and less labor-intensive than stone, concrete could easily be used to create Roman-inspired arches, supporting a Neoclassical architectural theme that was readily adapted to bridges.[46]

City planning throughout the country was also inspired by the event and by the redesign of Washington, D.C. in 1901 by the McMillian Commission. The use of professional engineers, architects, planners, and landscape architects were given a boost by the City Beautiful Movement. Cities throughout the country began to hire these professionals to develop and make improvements in community planning and design. Typically, these plans included a monumental civic center with distinguished government buildings. In addition to grand designs for government buildings, City Beautiful plans often included large park networks, parkways, and boulevards.[47] City Beautiful designs focused on aesthetics in urban spaces and resulted in the addition of Classical Revival architectural ornamentation to engineering designs of public works, such as bridges.

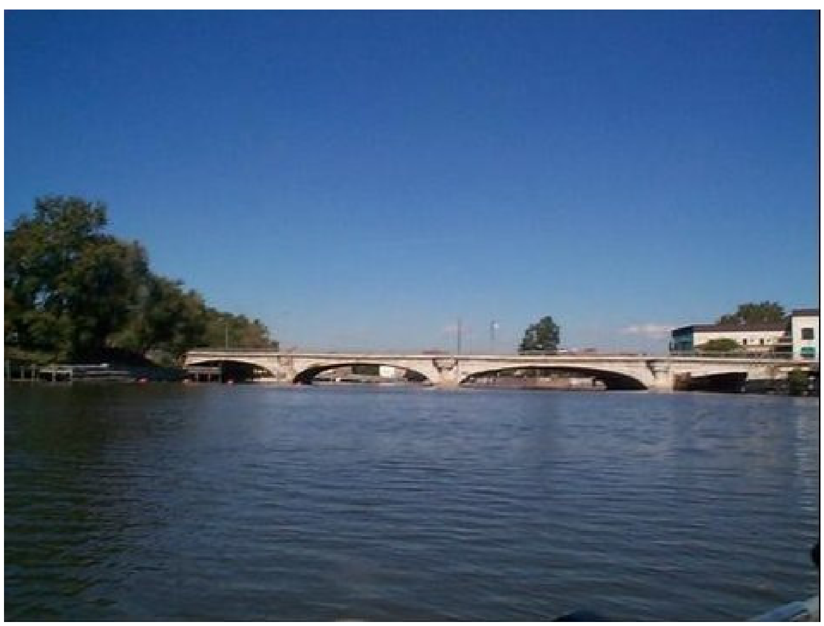
Examples of the City Beautiful Movement in Indiana are seen in public works projects produced by park boards in Indianapolis, Fort Wayne, and South Bend. These park boards were led by strong advocates for City Beautiful design. The park and boulevard systems in Indianapolis and Fort Wayne are listed in the National Register.

Around 1895 J. Clyde Power was chosen by Indianapolis to be the engineer and superintendent for the city's parks. Power, like many followers of the City Beautiful Movement, wanted aesthetically pleasing parkway bridges and preferred the use of stone arches. However, the park board administered only a small portion of the city's bridges. The city and county also had jurisdiction over bridges within the city and were typically concerned with utility and efficiency, not aesthetics. However, many bridges near parks administered by the city and county incorporated City Beautiful design features into some bridge designs during this period.[48]

In 1909 Indianapolis hired landscape architect George E. Kessler, to develop a park and boulevard plan for the city. Kessler's plan relied heavily on the incorporation of rivers and streams into the design for the park system. Numerous bridges were constructed, including the Capitol Avenue Bridge over Fall Creek, Marion County No. 2501F (NBI: 4900213), constructed in 1911. This concrete arch bridge had City Beautiful architectural elements, including its Neoclassical style with urn-shaped balustrades and applied decorative cartouches. Kessler's last design for Indianapolis was the Meridian Street Bridge over Fall Creek, Marion County No. 1809F (NBI: 4900633), in 1915.[49]

Capitol Avenue Bridge, Marion County No. 2501F (NBI: 4900213).

The sister cities of South Bend and Mishawaka were also influenced by the designs of the 1893 exposition. By 1906 South Bend began constructing City Beautiful bridges, including the Jefferson Street Bridge over the St. Joseph River, St. Joseph County No. 209 (NBI: 7100037). City Beautiful bridges were also constructed in Fort Wayne.[50]



Jefferson Street Bridge, St. Joseph County No. 00209
(NBI: 7100037).

E. The automobile age: from the beginning to the Great Depression (1890s-1929)

(1) Good Roads Movement

Although the construction of modern roads and highways is often associated with the development of automobile travel, the earliest promoters of good roads were bicyclists in the 1880s and 1890s. Indiana had 17 manufacturers of bicycles and parts by 1895 and Hoosier cyclists established a state division of the League of American Wheelman, the national cycling organization.[51] The league produced the first modern road maps, founded the predecessors of many of today's automobile clubs, and was the first organized protagonist for better roads. The National League for Good Roads was founded at a national conference in 1892 of the National Grange of the Patrons of Husbandry.[52] The National League for Good Roads published the *Good Roads Magazine* to promote its ideas, which helped spread their message.[53] The push for improved roads was also moved along by the federal government's establishment of Rural Free Delivery mail service in 1896. Since a mail route had to be passable in all weather, the designation of a road as a mail route became an incentive for improved surfaces.[54]

The invention of the automobile and the rapid expansion of its use both ended the bicycle era and inaugurated a long-term effort to enlarge and improve the country's highway system. The widespread interest in promoting improved roads, first by cyclists and then by auto enthusiasts, was known as the Good Roads Movement.

Pioneer Indiana inventors, often associated with carriage or bicycle manufacturers, experimented in the 1890s with self-propelled predecessors to the automobile. Charles H. Black built a primitive "self-propelled carriage" in 1891. David M. Parry designed an "electric chair-car" in 1892. In 1894 Elwood Haynes, the best known of the state's automobile pioneers, successfully drove a gasoline-engine-powered vehicle through Kokomo. A year later, Haynes and others had begun manufacturing autos. The Haynes venture soon was followed by other Indiana manufacturers in the 1890s, including names that would become well known in the national auto industry, such as Willys-Overland and Studebaker.[55]

In 1904 there were over 55,000 vehicles in use across the United States. To the north, in Detroit, Michigan, large-scale car manufacturing began in 1908 when Henry Ford introduced the low-priced, mass-produced, Model T, a car the average person could afford.[56] Thanks to Ford's production methods and inexpensive Model T, the number of autos on American roads skyrocketed to a half million by 1910.[57]

By the early twentieth century, road improvement was recognized as more than just a local problem. Increasing numbers of drivers from the city were contending with muddy and impassable roads or damaging the macadam and gravel surfaces of rural roads. Together with farmers, drivers from the city called attention to the need for rural road improvement, largely for those roads connecting farms with towns and railroad stations that had been intended for horse-drawn vehicles. Gathering strength with the automobile interests, the Good Roads Movement led to the formation of other organizations, including the American Automobile Association in 1902, the American Association for Highway Improvement in 1910, and the Indiana Good Roads Association in 1910.[58]

The national and state groups worked to designate, promote, and improve a network of highways. These organizations promoted their routes through published guidebooks that advertised the group's highway by offering route directions and identifying locations of tourist services and sites of interest. Two national guidebook series identifying routes throughout the country were the *Tourist Information Bureau* and the *Automobile Blue Book*. In addition to the published road and route guides, gasoline, oil, and tire companies often published state maps identifying early named highways. These state maps provided information on a variety of highways, but also served as a marketing piece and included the location of the sponsoring company's service stations.

Nationwide, farmers, bicyclists and automobile owners, local commercial clubs, business associations, automobile clubs, and merchants often contributed labor and funds to bring major roads through their towns and improve local roads. Despite the early efforts of these groups, only 154,000 miles of the country's over 2-million miles of road were improved in 1904.[59]

Largely absent from the list of promoters of improved road surfaces and extensive highway networks was the federal government, which had opened the Office of Road Inquiry (ORI) within the U.S. Department of Agriculture (USDA) in 1894 (discussed below). The federal effort focused on farmers and rural farm-to-market roads, believing that interstate transportation needs would continue to be served by the railroads that were then the reigning carriers. The alternative vision of an automobile (and truck)-dominated transportation system involving major, paved, interstate highways was not fully shared by the federal administrators, despite their own engineers' understanding of the need for improved roads for autos.[60]

(2) Transcontinental highways: Lincoln Highway and Dixie Highway

For Indiana, as for the nation, the initiation of the named transcontinental highways during the pre-World War I era represented the high point—the "most successful private roads campaign"—of the Good Roads Movement.[61] The Lincoln Highway in particular was an "object lesson" road, intended to demonstrate an interstate "system" at a time, around 1912, when its promoters felt that the current effort among states, local governments, and the federal government was spending too little and taking too long to produce the large, national road system considered necessary in the face of rapidly expanding auto travel. "Here was a start toward an adequate American highway system," wrote Austin Bement, vice president of the Lincoln Highway Association.[62] The Lincoln Highway and Dixie Highway are especially important for Hoosiers because the two have significant state roots in their Indiana founder, Carl G. Fisher.

Carl Fisher was the founder and owner of the Prest-O-Lite Company, which produced a patented lamp that would be known as the sealed-beam auto headlight. Prest-O-Lite was one of the many manufacturing companies that grew up around Indiana's automobile industry in the early twentieth century. Along with auto owners and drivers, manufacturers sought better roads for their products.[63] Fisher was among the most energetic of the early entrepreneurs and promoters of autos and improved roads. In 1909, partnered with James A. Allison of Allison Engineering Company, Fisher opened the Indianapolis Motor Speedway. Two years later in 1911 the two staged the first 500-mile race on the track that had now been improved with brick paving—symbolic of the move to hard-surfaced roadways more appropriate than gravel for autos.[64]

From the earliest years of automobile travel it had become increasingly clear that dirt, gravel, and stone-surfaced roads were inappropriate. Besides producing clouds of dust and dirt, they deteriorated rapidly under increasingly heavy use by cars and trucks, degenerating into hopelessly rutted and impassible surfaces. Fisher, along with others, promoted new hard-surfaced highways and transcontinentals, such as the Lincoln and the Dixie, as ideal ways to demonstrate the effectiveness of new paving, engineering, and signage.[65]

Unlike the federal Interstate Highway System introduced in the 1950s, which constructed new roadways within newly acquired ROWs, the named highways of the early twentieth century followed existing roads. A beginning and ending city would be designated and existing roads between the two points would be identified and continuously marked with the name of the new highway. New construction in specific areas might be used to create a more efficient route, or some existing roads might be paved or otherwise improved, but for the most part the early transcontinental highways simply marked a disparate line of roads to form an easily followed, point-to-point route. In addition to the well-known Lincoln and Dixie highways discussed below, there were many other named highways, also called "auto trails." By 1923 Indiana had more than 40 named roadways, including Hoosier Highway, Ohio-Indiana-Michigan Way, Jackson Highway, Range Line, Liberty Way, National Old Trails Route, Adeway, Ben Hur route, and others.[66] Figure 4 illustrates the proliferation of roads by 1926.

(a) Lincoln Highway

The Lincoln Highway, developed and promoted in the early twentieth century, was to be paved, toll free, and direct across the United States. The Lincoln Highway Association and community supporters along its route propelled the highway into national significance as a major east-west transcontinental route. Within the first few years of route designation, thousands of people left Times Square in New York City and set out for the West Coast. The Lincoln Highway crossed the northern part of Indiana through Fort Wayne and Valpariso.

In the early twentieth century few people seriously considered driving an automobile across the country. Although roads existed across the United States, there were no formally designated or direct transportation routes, and the majority of the roads were not paved. Any traveler contemplating such a journey first had to work out a possible route from the patchwork of connections between cities and then hope that the roads were passable when one finally arrived. After that, the traveler hoped for good locations to eat and sleep, since there was little way of identifying them in advance.[67]

In September 1912, Carl Fisher conceived of a paved and marked transcontinental highway that would be toll free, for use by all who sought the most direct route from the East to the West Coast. He dreamed of developing a paved road across the country for use by travelers. That fall Fisher presented his plan at a dinner party. With open ears, leaders of Indianapolis automobile manufacturing industry listened to the idea, praised the plan, and began offering their assistance. The businessmen knew, however, that the outcome of the highway depended not only on their own enthusiasm and capital, but also the support of the general public. Due to the overall lack of improved roads, Fisher had no problem gaining interest from the people. Soon after, his dream of building a passable route from one coast to the other became a nationwide initiative to connect the oceans.[68]

Three months after Fisher's initial announcement, he received a letter from Henry B. Joy, president of the Packard Motor Car Company. The letter not only contained a pledge of money, but it also offered an idea that would further the public's excitement and have profound patriotic appeal.[69] With the 1909 centennial of Abraham Lincoln's birthday in mind, Joy's intention was for the highway to memorialize the past president.[70] Knowing that the original name, the Coast-to-Coast Rock Highway, captured the idea of a hard-surfaced road but was not particularly inspiring, Fisher was quick to adopt the new name of the Lincoln Highway. The following spring Fisher called together several automobile manufacturers and other highway supporters for informal meetings. It was not until the July 1, 1913, meeting, however, that the Lincoln Highway Association was officially organized. After electing officials, the men announced the purpose of their organization. The statement read as follows:

> "To procure the establishment of a continuous improved highway from the Atlantic to the Pacific, open to lawful traffic of all description without toll charges: such highway to be known, in memory of Abraham Lincoln, as 'The Lincoln Highway.'"[71]

Although they had announced the highway's establishment, the Lincoln Highway Association still did not have a formal route mapped. The highway was to start at New York City and end at the western terminus of San Francisco, the location of the 1915 Panama-Pacific Exposition. The Association's goal was to have the route paved in time for the 1915 Exposition. With the termini announced, the organization did not disclose any information about the points through which the route would pass between the two coasts. Knowing that the success of the project depended on contributions of the public on a nationwide level, Fisher first wanted to gain support from the nation in its entirety, not only the towns, counties, and states on the route. The Association appointed a team to research and determine the highway's exact route. [72]

Henry Joy, the first president of the Lincoln Highway Association, stated that the most important factor in determining the route was directness. Other factors included the need to take advantage of easy terrain and natural paths while avoiding the congestion of large cities. By August 26, 1913, the route was announced. The coast-to-coast highway started in Times Square and traveled west for 3,389 miles, ending at Lincoln Park in San Francisco. After going through New Jersey and Pennsylvania, the route traversed the Midwest states of Ohio, Illinois, Indiana, and Iowa. From there, the route turned southwest to cross the Missouri River and enter the West. The Lincoln Highway crossed Nebraska and went on to California via Wyoming, Utah, and Nevada.[73]

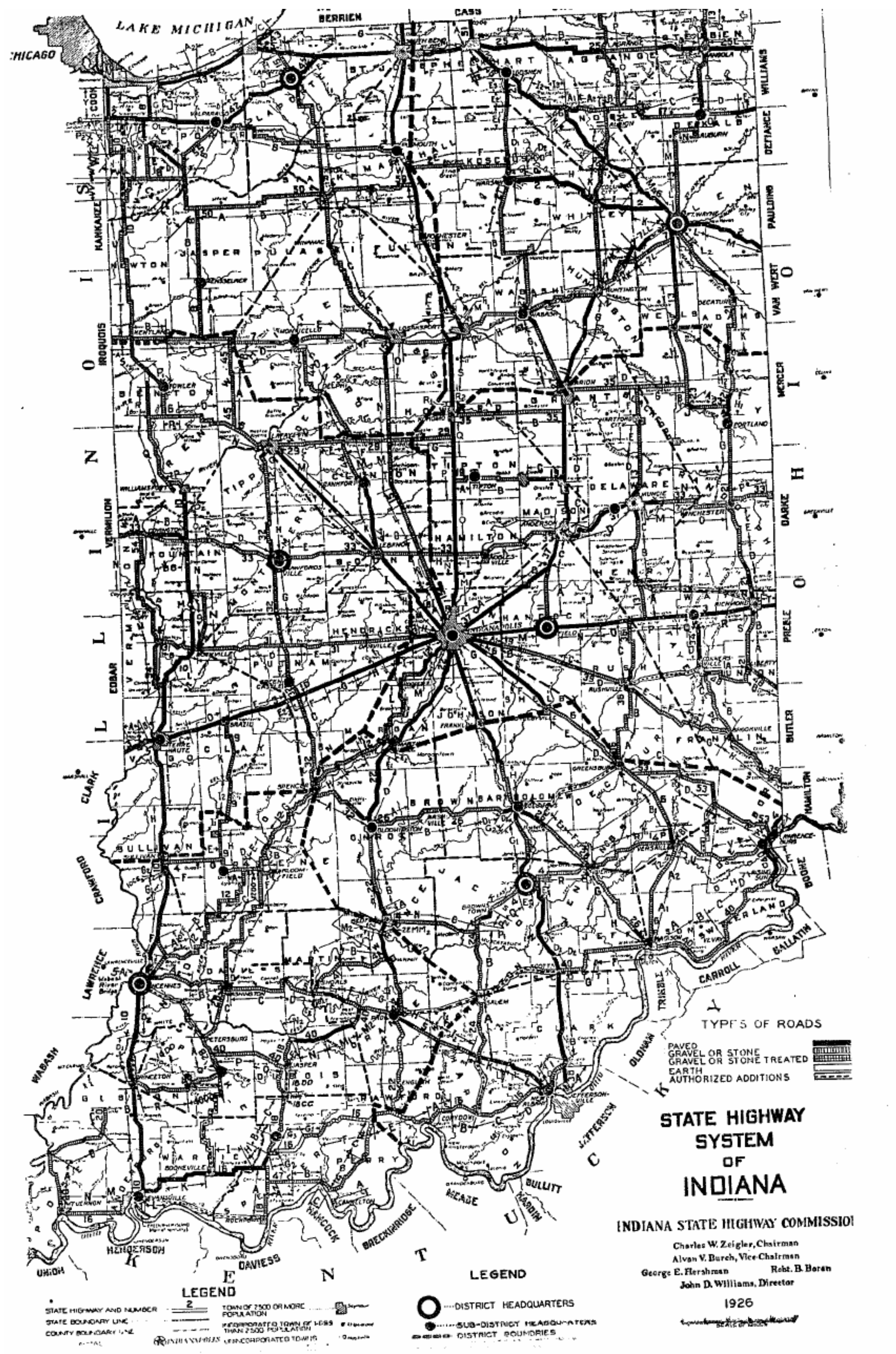


Figure 4. 1926 Indiana State Highway Map

When first designated in 1913, the Lincoln Highway route largely followed roads parallel to railroad lines on its way west through Ohio and on to Fort Wayne, Indiana, the largest city on the highway between Pittsburgh and Chicago. It followed a circuitous route across northern Indiana from Fort Wayne to Valpariso and exited the state on the west, south of Chicago. Eventually it followed a much straighter line between Fort Wayne and Valpariso along the Pennsylvania Railroad through Columbia City, Warsaw, and Plymouth. With the final highway marking in 1928, the Indiana alignment had become 20 miles shorter. Later this route was largely designated as U.S. 30.[74]

The Lincoln Highway Association developed the concept of "Seedling Miles." The Association preached that "Great oaks from little acorns will grow; long roads of concrete from 'seedling miles' will spring."[75] The concept of seedling miles was to hard-surface small sections of road through donations which would, in turn, encourage communities and states to continue improvement along the entire route. In 1916 *The Complete Official Road Guide of the Lincoln Highway* described seedling miles as "strips of standard concrete road surface." The road guide further explained that the first seedling miles were constructed with cement donated by the Lincoln Highway Association and cement producers with hopes that the traveler would "appreciate the value of hard-surfaced roads" and encourage similar construction throughout other sections of dirt road through donations.[76]

In Indiana, St. Joseph County credited a 1915 seedling mile donation with initiating the concrete paving of a 15-mile section of Lincoln Highway and inspiring the financing of an additional 50 miles of pavement.[77] Later, in the 1920s, a 1.33-mile section of rural road near Dyer, Indiana, was upgraded into the "Ideal Mile" to demonstrate the highest standards as a demonstration project. It was made into a four-lane concrete highway with pedestrian walkways and electric lights. Eventually becoming part of U.S. 30, it remained in use until 1997 when it was replaced in a road-widening project.[78]

(b) Dixie Highway

Carl Fisher, in short order, had created the Indianapolis Motor Speedway, paving it with bricks, and had been instrumental in conceptualizing, planning, and developing the Lincoln Highway. He had accomplished these feats in the decade or so following his founding of the successful Prest-O-Lite Company in about 1904 (he sold the company to Union Carbide in 1909).[79]

He was not finished. Between 1910 and 1912 Fisher built a home on swampy property he had acquired near Miami, Florida, and which he called "Miami Beach." As part of his development plans for the Florida property he proposed a north-south interstate highway at the 1914 American Road Congress. It would be a tributary to the Lincoln Highway, then under development, connecting in Indiana, just outside Chicago, and providing a long route through the south all the way to Miami. This would be a great boon to Indiana, already crossed by the National Road and the Lincoln Highway, and now to add a north-south highway and become a national crossroads.[80]

Originally called the "Cotton Belt Route," Fisher promoted his idea across southern states. Indiana's governor, Samuel Ralston, embraced the concept and convened an organizational meeting in April 1915 to form an association for what was then being called the "Dixie Highway." Fisher and

Ralston joined others in Martinsville, Indiana, to inaugurate the new Miami to Indianapolis Dixie Highway in December 1916. Initially, the name proposed for the road was “Hoosier Land-to-Dixie,” according to *The Dixie Highway* magazine in 1925.[81]

The Dixie Highway, as conceived by Fisher, was more clearly directed at a single real estate and tourism objective—Fisher’s own Miami real estate—than the Lincoln Highway, although the Lincoln Highway concept also was motivated by commercial interests. Unlike the Lincoln Highway, the Dixie Highway took a more varied and irregular route—two routes, in fact, with Eastern and Western divisions. The Western Division traversed Indiana from South Bend at the north, through Plymouth, Logansport, and Michigantown to Indianapolis, and then on to Martinsville, Bloomington, Bedford, and Paoli, to Louisville, where it continued into Kentucky and south.[82] The Eastern Division ran through Ohio with an east-west connector route between Dayton and Indianapolis. By 1917 the Dixie Highway Association had extended the route north to Michigan, Sault Sainte Marie, and the Canadian border, allowing promoters to claim a transcontinental connection. Initially the two routes included about 4,000 miles, but many cities and communities wanted to be part of a potentially lucrative system. By 1919 the Dixie Highway had become more of a network than a highway, and various connectors, additions, and a third Carolina Division had increased the overall mileage to 5,700.[83]

As it turned out, the Dixie Highway in the state of its chief promoter, Fisher, was much less successful than in some other states, particularly in the South. The reason for the Dixie’s lackluster history in Indiana is readily apparent in today’s world of high-speed expressways and interstates, but was less clear to the road’s boosters at the time. Even in 1917, when the first ISHC designated the state’s five Main Market Highways, the best and most direct north-south route was clearly the one identified as Road No. 1, which became U.S. 31. It was the most improved and most direct—therefore fastest—route. With their minds on commerce, however, the Dixie’s developers selected roads that wandered off to tourist attractions, largely at Fisher’s insistence. Dixie travelers, the developers imagined, might want to follow the historic Michigan Road, visit a mineral spa, the university town of Bloomington, or the French Lick Springs Hotel, a resort owned by Dixie chairman Thomas Taggart. The more direct route alignment—the eventual U.S. 31 route—traversed uninteresting sections of the state and therefore seemed less appropriate for Dixie designation.[84]

In 1924 the Dixie’s Western Division, which included Indiana, incorporated 66 different numbered highway segments. Motorists, seeking the most direct route, were confused. Making matters worse, the U.S. 31 route started out as the most improved (i.e., paved) north-south highway and upgrades continued regularly. The Dixie sections, on the other hand, were improved in haphazard fashion and their construction conditions were frustratingly unpredictable. Eventually, travelers began to think of the U.S. 31 route itself as the “Dixie Highway,” regardless of what had been planned and designated. The actual Dixie route fell into obscurity as speed, efficiency, and the roadside availability of auto-travel necessities (gas, food, and lodging) took precedence over tourist interests.[85]

The two private transcontinentals shared the goal of being permanent, improved highways, capable of inspiring long-distance automobile travel over substantial and sustained roads. The issue of physical construction of a paved, concrete roadway for automobiles is more prominent in the literature of the Lincoln Highway, but the general recognition of permanence is apparent in the Dixie Highway prose poem published in *The Dixie Highway*'s March 1925 issue, entitled "The Concrete Road": "I am a concrete road—a thoroughfare of human endeavor…."[86]

As with the Lincoln Highway, the original enthusiasm for the private transcontinentals faded as federal and state highway agencies assumed control over systems, design, construction, and finance of the nation's—and Indiana's—highway system.

(3) Early state and national highway agencies

The federal government formally became involved in roads in 1893 with the formation of the ORI within the USDA. ORI engineers supported the Good Roads Movement and the office served as a source of technical information regarding roads. The ORI was involved in data collection and released bulletins and circulars addressing road construction and issues related to the administration of roads.[87] As part of this effort, examples of road improvements were constructed with assistance of the ORI throughout the country.[88] These roads were among the first constructed by the federal government since the work on the National Road.

ORI was renamed the Office of Public Road Inquiry (OPRI) in 1899 and continued with technical and promotional efforts to improve roads.[89] One effort of OPRI was to develop a materials-testing laboratory to test samples and identify suitable road materials. In 1905 the Office of Public Roads (OPR) was created by the passage of the Agriculture Appropriations Act, which terminated the OPRI and established a permanent federal road agency with an annual budget of $50,000.[90] Based on continued testing, OPR issued material specifications and testing procedures, as well as construction guidelines in 1911. Bridge specifications were subsequently provided by the office. The ORI and its successors were the predecessors of the FHWA.

Chronology of national highway agencies

The federal government formally became involved in road construction activities in 1893 with the organization of the office of Road Inquiry (ORI). This agency underwent several name changes and reorganizations over the years. In 1939 the agency was named the Public Roads Administration (PRA), which it remained until it became the Bureau of Public Roads (BPR) in 1949. The BPR is the federal agency that provided the Indiana State Highway Commission (ISHC) and other state departments of transportation guidance on bridge design, material use, and innovations. BPR evolved to become the present day FHWA in 1967.

1893-1898	Office of Road Inquiry
1899-1905	Office of Public Road Inquiry
1905-1915	Office of Public Roads
1915-1918	Office of Public Roads and Rural Engineering
1918-1939	Bureau of Public Roads
1939-1949	Public Roads Administration
1949-1967	Bureau of Public Roads
1967-present	Federal Highway Administration

"Names of the Nation's Highway Agency-1893 to the Present," *FHWA By Day*, n.d., <www.fhwa.dot.gov/byday/acronyms.htm> (Accessed 13 March 2002).

(4) Indiana State Highway Commission

The cross-country memorial highways, of which the Lincoln Highway was the most prominent example, were “the best indication” of support for good roads everywhere in the mid-1910s, observed Bruce Seely in *Building the American Highway System*. Beyond simply interest and support, however, the “real proof of change came with the introduction of sixty road bills in Congress” in a 6-month period in 1911 and 1912. There was a “widespread demand” for congressional action, reported *Engineering News*.[91]

The demands for action were answered in the Federal-Aid Road Act of 1916. Limited federal and state funds were available for road construction in the late nineteenth and early twentieth century. In 1916 Congress passed the first formal highway policy with a regular appropriation of funding to the states. By this time the number of automobile registrations in the country had reached 2.3 million and the auto industry and motorists were heavily lobbying for programs and funds to improve roads.[92] The Federal-Aid Road Act, signed by Woodrow Wilson on June 11, 1916, was the first time the federal government was directly involved in road-building efforts. Approximately $5 million was appropriated the first year with the funding escalating in annual steps to total $75 million. Funding, managed by the Secretary of Agriculture, was allocated by a formula based on a state's population, land area, and road mileage. Under this act the federal government would finance up to 50 percent of the cost of construction, not to exceed $10,000 per mile.[93]

In order to obtain federal funds, each state's highway commission had to meet the federal government’s standards and approval. To participate in the Federal Aid Program, a state had to:

- Maintain a state highway department to administer the Federal-Aid Act.
- Assume responsibility of all roads on which federal funds were spent (this could be delegated to local governments).
- Classify eligible mileage in eligible systems based on traffic needs and services rendered.
- Agree to uniform standards of construction and design.
- Meet inspection requirements before bills were paid.
- Agree to further diversion of road funds to non-road purposes after 1935.
- Match federal funds under mutually acceptable standards.

State highway commissions had the responsibility for the preparation of plans and specifications and construction and maintenance on federal-aid projects, while the federal government held the right to inspect all projects.[94]

Initially the federal government, through the ORI (after 1899 the OPRI), had been laboring to stimulate state interest in roads by organizing state road conferences and addressing legislatures and other meetings. By 1904 Indiana was the only state north and east of the Mississippi that did not provide assistance for roads. Iowa had created a state highway commission in 1904, followed by Indiana's neighbor, Illinois, in 1906. Ten years later the federal-aid bill was passed and Indiana still did not have a state highway commission. Indiana's delay may have been related to the fact that, prior to advent of federal aid, many early state commissions received little or no funding or power from their legislatures. In fact, Indiana became the last state to establish a commission.[95]

In 1914 at the urging of supporters of a state highway commission who assembled for a conference in Indianapolis, Governor Samuel Ralston had appointed a special five-member group to look into the matter.[96] "The time has come," declared the commission's 1914 report, "when a more equitable and uniform system of making and maintaining the public roads in the State should be provided." Observing that "The State does nothing towards the construction or maintenance of our public roads," the report urged the establishment "of a state department of roads" by the Indiana legislature. "All the States in the Union (except six) have established and maintain state highway departments empowered to co-operate with the general government through the Government Good Roads Bureau, established under the supervision of the Agricultural Department."[97]

As defined in the 1914 group's report, such a new department—or highway commission—would bring new state resources, including a qualified highway civil engineer, into the road-building process that was then completely in the hands of townships and counties. State involvement would add some consistency and professional expertise to an increasingly complex and confusing crazy quilt of gravel, stone, concrete, brick, and otherwise paved and unpaved roads amongst Indiana's townships and counties. Not only was the paving inconsistent among townships and counties, but the appropriateness and reliability of various paving materials was uncertain. A state highway commission would test materials, either in "the laboratory at Purdue University, or some other laboratory within the state." Perhaps most important, however, was that the governor's commission could see that a federal-aid bill would be coming out of Congress sooner or later and Indiana would need a federally approved highway commission to qualify for any funding.[98]

Spurred on by the 1916 Federal-Aid Road Act, the Indiana legislature moved forward, passing in 1917, "An act creating a state highway commission, providing for the construction, reconstruction, maintenance, repair, and control of public highways, and providing for co-operation with the federal government in the construction of rural post roads." It was identified in statute as the Dobyns-Duffey Highway Commission Law, became effective by the governor's proclamation on June 1, 1917, and created the ISHC. Among other things, the four-member commission was empowered to appoint a state highway engineer and to "designate [for the governor's approval] the main roads of the state, which shall be known as 'main market highways.'" The system of roads was to be interconnected and not exceed 2,000 miles. The main market roads were to be determined through an analysis of "lines of travel connecting main market centers and the kind and volume of traffic."[99]

Control over the state highway system was divided between state and local control. State and federal aid would be available for up to half the cost of new road surfaces and bridges that followed commission specifications and plans on the designated main market roads. Once ISHC became involved, however, a county could award a road or bridge contract based only on specifications and plans that the state's engineers had already approved, thereby giving the ISHC a veto over materials and design.[100]

The new commission inspected about 4,000 miles of Indiana roads and, in September 1917, delineated and designated five main market highways. The system totaled 898 miles, of which 120 miles were within cities and towns. A map of the highways was published in the commission's 1917 annual report.[101] Figure 5 illustrates the main market highways.

- Road No. 1. South Bend, Indianapolis, and New Albany Route—265.60 miles
- Road No. 2. Dyer, South Bend, and Fort Wayne Route—78.10 miles
- Road No. 3. Terre Haute, Indianapolis, and Richmond Route—148.70 miles
- Road No. 4. Evansville, Seymour, and Lawrenceburg Route—233.70 miles
- Road No. 5. Vincennes, Washington, and Mitchell Route—72.50 miles

This initial route selection was neither accidental nor random. Road No. 1, later U.S. 31, was the major north-south route that was related to the Dixie Highway network. Road No. 2, later U.S. 30, was the east-west route in the north and a component of the Lincoln Highway. Road No. 3, later U.S. 40, was the east-west route in the middle of the state and part of the National Road. Road Nos. 4 and 5 constituted the southern east-west route and later became U.S. 50.

The commission stated that the improvement of the newly designated roads "will be undertaken in a systematic manner, according to modern practice, and with a view of ultimately having a uniform system of highways connecting the main market centers." The commission had the option of adding more routes until the authorized 2,000 miles had been designated.[102]

The lead engineers for the new ISHC, and the individuals who surveyed the roads, were William S. Moore and William H. Rights, two graduates of Purdue University. Moore, who had designed several bridges in Indiana, was chief engineer. Rights became his assistant engineer.[103]

As it turned out, the work of the newly created ISHC came to a halt one year later on June 1, 1918, after a lawsuit questioned the constitutionality of the state highway law. The commission's engineers had been in the midst of detailed surveys of the main market roads and had also prepared plans for several bridges. At the same time, the flow of road and bridge materials was complicated by World War I. The two engineers went their separate ways while the ISHC awaited a resolution of the legal question.[104]

By the spring of 1919 the constitutional question had been bypassed and forgotten when the legislature and the governor reorganized ISHC under a new and substantially different law. The 1919 state highway act created a State Highway Fund, which drew revenue from vehicle license fees, chauffeur license fees, the inheritance tax, and a general levy. Instead of heading the ISHC as before, the chief engineer was now in charge of the division of construction. The number and scope of main market roads was expanded to connect all county seats and cities with a population of 5,000-plus with trunk highways from other states.[105] In the end, the 1919 ISHC report concluded, the

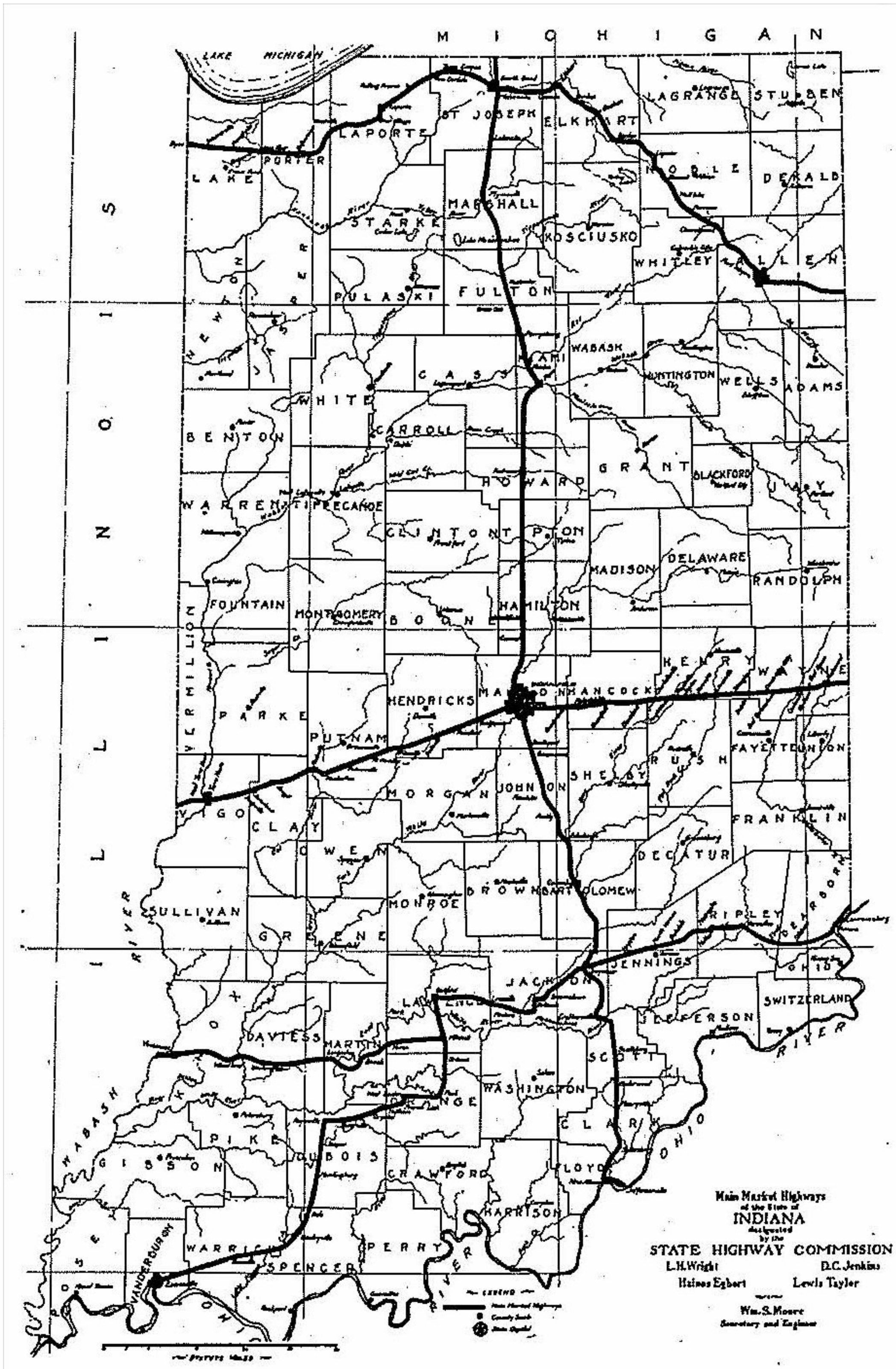


Figure 5. 1917 Main Market Highways Map

“network of highways…will connect each and every market center of the state.” Significantly, governance of the state highway system was shifted decidedly to the state level, ending the 1917 involvement of counties. Now the main roads would be constructed, reconstructed, repaired, and maintained by the state highway commission out of the state highway funds. The occasional state control over county design remained.[106] “All highway work,” the chief engineer reported, “has been standardized to a great extent to comply with the requirements of the U.S. Bureau of Public Roads (BPR).”[107]

Federal funding for the highway construction was continued by Congress with the passage of the Federal Highway Act of 1921. This act provided states financial aid for the construction of highways under the 7-percent system in which each state was eligible for assistance for the construction of 7 percent of its highways. Within two years, each state was required to designate 3 percent of their primary roads and 4 percent of their secondary roads as part of the federal-aid highway system and as a result, these roads were eligible for assistance.[108]

Federal funding was to be matched by state funds on a 50/50 basis. Post roads were designated as important interstate throughways and were to be developed into an integrated national road system that would allow easy intercommunication throughout the country. Road designs were required to adhere to the federal government's standards for minimum width, grade, and adequacy of roadbed type for the traffic load. States were required to submit their plans to the United States Secretary of Agriculture for approval.[109]

The administrative structure of ISHC remained essentially unchanged from the 1919 reorganization, through the twenties, to the early 1930s. However, the transportation world in which ISHC operated changed dramatically. In 1919 the nation was emerging from World War I and the so-called “car culture” was only beginning its dramatic expansion. By the end of the twenties the Depression was looming and change was again on the horizon. Between World War I and the Depression, ISHC existence was largely linear: there was more and more traffic with larger and heavier vehicles. Trucks and buses especially were hard on roads. ISHC could never seem to catch up with road improvements to match the public needs and demands for more and better roads and bridges. According to ISHC, the roads and bridges inherited from counties were invariably inadequate in size, capacity, or both—in short, “worn out.” “There are great numbers of culverts and old bridges which are ready to fall down and which will have to be replaced,” ISHC’s 1920 annual report declared.[110]

Safety for the highway user, while always a concern, became increasingly important during the 1920s with changes in automobile engineering and proliferation. Early roadway approaches to bridges had been designed for horse-drawn wagons and early autos, and these alignments became a growing problem as vehicle speeds increased. By the late 1920s ISHC would state that “Especial attention is being given to the alignment over bridges and the grades approaching them so that traffic will not be slowed down in any way.” New and improved roads meant more grade separations between highways and railroads. All of these considerations required funds and there never seemed to be enough federal and state money to do all the work.[111]

The 1919 legislature, which funded the State Highway Fund with revenue from vehicle license fees, chauffeur license fees, inheritance tax, and a general levy, could hardly have foreseen the burgeoning need for road funds in the 1920s. In 1923 the legislature instituted a 2-cent-per-gallon gas tax to replace the inheritance tax and general levy. The counties received a predetermined amount of the gas tax receipts instead of a percentage, leaving the state with whatever was left. It was not enough for the state. The rate increased to 3 cents per gallon in 1925 and the distribution was changed to a third for counties, cities, and towns, with two-thirds to the state. In 1929 the tax was raised to 4 cents, with the state getting 75 percent and counties, cities, and towns 25 percent.[112]

In 1920 ISHC and the governor had designated a network of state roads approximately 3,200 miles long, only three years after the system had been expected to top out at 2,000 miles. That same year, the state assumed responsibility for maintenance and improvements of all state-designated roads, most all of which were surfaced with gravel or rolled, crushed rock (macadamized), which was not the desired surface for automobiles.[113] The ISHC budget was largely devoted to paving. By the mid-1920s some 1,200 miles were hard-surfaced, a number that grew to over 2,100 miles at the decade's end.[114] By 1930 the state highway system had grown to about 6,000 miles, an expansion of almost 90 percent from the 1920 mileage.[115]

Early on, ISHC realized the paradox inherent in road paving and bridge improvements: the better the road, the more traffic it attracted. The problem was compounding itself with each passing year as ISHC never seemed to catch up. In 1922 ISHC calculated that highway traffic was increasing at 20 percent a year since 1919.[116] A year later the estimate of annual increase was 30 percent a year on all roads and "as much as 300 percent on some of the more important lines." Between 1920 and 1929 automobile registration increased 150 percent, truck registration increased almost 300 percent, and bus registrations—which were not even recorded separately until 1924—had reached 1,024 by 1929.[117] In addition to volume of traffic, ISHC reported, "an increased burden is also put upon our state roads in the increased speed. The rate of speed has been doubled and distances traveled materially lengthened."[118]

Having complained annually about the burdens of non-stop growth as a justification for more money, ISHC tried a positive approach to funding in 1928 and listed the advantages of an improved highway system: increased postal service, transportation for "the consolidation of our public schools," a "wider social view of life," and wider distribution of "the products of the farm and workshop." For transportation of people and goods, highways replaced rails and buses and trucks replaced railcars, ISHC said, and better highways meant improved transportation efficiency and cheaper products. In the view of the highway commission, the state highway system was responsible in many ways for the improved standard of living in the 1920s. Assuming everyone agreed with this idea of positive growth through highways, ISHC declared that "an enlarged program is very desirable" and proceeded to lay out a program for more highway funds, paid largely through increased auto license fees.[119]

ISHC repeated much the same story in the next annual report which closed out the fiscal year on September 30, 1929, one month prior to the infamous Black Tuesday and the stock market crash. The implications of the coming Great Depression for ISHC were not yet apparent and the optimism of the 1920s with "the dividends of improved highways" still seemed appropriate.

F. New Deal Era through World War II (1930 to 1945)

The 15 years between the 1930s and the mid-1940s include three of the most momentous events in twentieth-century American history: the Great Depression, the New Deal, and World War II. They profoundly affected all aspects of the nation's life, and highway transportation in Indiana was no exception. Unlike many non-governmental parts of the national economy, which suffered business failures and unemployment, the work of building and maintaining public roads and bridges was well-funded and very active. Highways became a focus—and a direct financial beneficiary—of government efforts to combat unemployment and provide emergency relief. Federal dollars flowed into road and bridge projects, first through new relief programs for the jobless in the 1930s and then through defense dollars for wartime projects in the 1940s.

(1) New Deal federal relief programs

Triggered by the stock market crash on October 29, 1929—Black Tuesday—the Great Depression was an era of widespread unemployment and economic distress. It began during the administration of President Herbert Hoover. Despite the fact that he generally opposed large-scale, public relief projects, Hoover worked to stimulate employment by authorizing large sums for highway projects, beginning in 1930. Hoover's highway spending was minor compared to what President Franklin Delano Roosevelt's administration would provide later, but it firmly established highway work as the leading solution to unemployment.[120]

While some spending was made directly by federal agencies, other highway dollars were passed through the states, which had to provide matching funds. The depressed economy made it hard for states to match available federal funds. Cities and counties had a particularly difficult time throughout the 1930s and their funding levels by the end of the decade remained below that of 1929. Nevertheless, federal highway funding overall was so powerful that almost no other area of the economy "recovered" so quickly. Between 1930 and 1940, surfaced highways in America doubled from 694,000 miles to 1,367,000 miles.[121]

Federal spending was not launched full force until President Roosevelt came into office in 1933 and began to implement what he had proclaimed when he accepted the Democratic presidential nomination earlier: "a new deal for the American people." FDR's New Deal has been synonymous with the infusion of federal power and money into the national economy.[122] Once the New Deal got underway the programs came in a rush of confusing names and associated acronyms often called the "alphabet agencies." Important agencies that funded road and bridge construction include:

- Public Works Administration (PWA). Created soon after Roosevelt took office, the PWA distributed nearly $6 billion for construction projects in the 1930s and in 1933 alone it accounted for a third of all construction in the United States. Funds were available on a 30-70, federal local, basis. From March 1933 to September 1936, PWA funds built 60,361 miles of roads and 2,641 grade-crossing viaducts nationally.[123]

- Federal Emergency Relief Administration (FERA). Created by Congress in May 1933, FERA empowered Roosevelt to spend $500 million in cash grants to state and city work-relief projects, providing one federal dollar for three local dollars. FERA ended in 1935.[124]

- Civil Works Administration (CWA). A short-lived program that lasted only from November 1933 to March 1934, the CWA nevertheless was a successful program that worked entirely on the federal level, employing workers directly rather than providing relief money. CWA workers constructed 250,000 miles of roads and streets.[125]

- Works Progress Administration, renamed to Works Projects Administration (WPA) in 1939. Roosevelt created the WPA through Executive Order in May 1935. WPA, along with the Social Security program, was intended to replace FERA (which ended in 1935) with a permanent program. It continued until 1943. The WPA built 572,000 miles of highways, 67,000 miles of city streets, and 78,000 bridges.[126] In Indiana, about half—49.3 percent—of all WPA funds went to roads and bridges, totaling $182,104,483 from 1935 through 1943.[127] The "WPA" acronym remains among the best-remembered of the New Deal alphabet agencies and is closely identified with many bridge projects, in part because of the identifying plaques placed on WPA-constructed structures.

- Civilian Conservation Corps (CCC). Created in March 1933 at the outset of the Roosevelt administration, the CCC was designed to provide jobs for men between the ages of 17 and 24 whose families were already on relief. It soon added veterans of the Spanish American War and World War I, without age restrictions. The CCC paid $30 a month and was under the administrative control of the U.S. Army. The CCC was organized into work camps for construction projects, including roads and bridges, usually administered by another agency. At its peak in 1935 the CCC employed a half-million men. Congress ended appropriations in 1942.[128]

Nationwide, federal relief programs kept the highway building boom of the 1920s alive through the 1930s, with 35 to 45 percent of all workers on federal relief building roads. At first, the funds benefited all areas except cities, but after 1935 federal dollars provided substantial road work in cities too.[129] Overall, the New Deal spending on highways through the federal relief programs slowly transformed and expanded the federal financial role beyond the ties with state highway systems and the basic federal-aid program begun in 1916. Because of changes in federal appropriations in 1933, the Bureau of Public Roads was required to devote some funds to roads outside the existing federal-aid system. Receiving aid now were farm-to-market roads in rural areas and railroad grade crossings and feeder roads to the federal-aid networks in cities. Because of Depression-related budget cuts on the local level, officials became dependent on the new assistance. By 1938 Congress had created a federal-aid secondary road system in response to this need. At the same time, federal funds also became increasingly available for city roads and streets and by the end of the 1930s cities, too, had become dependent on federal highway money.[130]

(2) ISHC in the 1930s: state, county, and city roads and bridges

(a) Centralization of funding and administration

The broad trend, from the 1920s to World War II, was toward the centralization of highway administration and finance at the state level, aided and facilitated by the federal government. The centralization was accelerated by the economics of relief spending, especially during the New Deal era beginning in 1933. The federal government could spend as it wished, without the restrictions on borrowing that were imposed on Indiana by the state constitution. The Indiana state and local governments could not borrow funds and were limited to their tax revenues. If local governments determined that relief efforts were a higher priority than roads and bridges, dollars would need to be shifted from roads to relief. Local governments, unable to borrow, could not afford to pay for both areas. As a result, responsibilities for—and control of—highway projects followed the source of funds, which increasingly was federal and not local.

At the state government level, Indiana experienced an immediate expansion of federal funds at the start of the Depression in 1930, thanks to a special allocation by the Secretary of Agriculture of $3.1 million to the state. These funds came on top of the regular federal-aid allocation, giving Indiana the large sum of $5.3 million at one time for the state system. The federal dollars would reimburse the state for half the cost incurred, not to exceed $15,000 per mile. Because of the Depression economy, ISHC estimated the total cost per mile to be only $25,000, meaning that they could use only $12,500 of federal funds per mile. At that rate, the state had to build even more miles to use up the appropriation. They needed "an unusually large federal aid construction program," according to the 1930 ISHC annual report.[131] In 1930 Chief Engineer William Titus reported paving 397 miles by September 1, "a record never before equaled by the department, both as to total mileage and early completion."[132] Depressed contract costs allowed ISHC to get more value for its construction dollar and, in 1932, paved 100 more miles than its budget had estimated.[133]

In 1932 ISHC formalized a three-part approach to relief: (1) adding local miles to the state system—almost 1,500 miles were added, (2) doing more contract construction, and (3) creating day-labor projects. In July and August of 1932 ISHC employed 8,000 men on an hourly basis for day-labor work. In July 1932 the federal Emergency Relief and Construction Act was passed, providing an additional $3 million for road construction while requiring higher wages with shorter work weeks for more workers with more hand labor.[134]

The situation was different at the local level, where county and city governments shifted their scarce property-tax dollars away from road and bridge construction and maintenance and into food, clothing, and housing.[135] In 1932 a special session of the state legislature transferred authority for all township roads to counties and, in the same year, prohibited counties from levying taxes for road finance, making them dependent on state allocations.[136] The ISHC now began to acquire roads from the counties, adding to its own demanding workload causing it to double its maintenance division in 1931 alone. In short order, township road responsibilities were moved to counties and county roads were increasingly absorbed by the state. Remaining county roads relied on state funding. In effect, this shifted local highway funding from local property taxes to the statewide user taxes on gas and license fee. The gas tax allocation, last changed in 1929 on the eve of the Depression, was revised in 1932 to reflect the relief-related financial needs of local governments. Now, half of the tax revenues would go to ISHC and half would be divided among the counties, cities, towns.[137] The allocation would be revised again in 1937 with the Motor Vehicle Highway Account established as a state general fund, which accumulated all vehicular revenues and redistributed a third to counties and two-thirds to ISHC after initial distribution of set amounts to the Division of Public Safety, the state General Fund, and cities and towns.[138]

The year 1933 brought the first of Roosevelt's New Deal agencies, but it was also a year of administrative changes for ISHC. A new state highway law in 1933 changed the four-person, part-time highway commission to a three-person, full-time commission and authorized additional state highway routes.[139] ISHC was decentralized into six districts, moving some responsibilities out of the central office in Indianapolis. Bridge and construction engineers, who had been responsible to Indianapolis, were now directly under the supervision of the district engineer.[140] Roads and streets in some cities now received state maintenance. The act expanded existing connections between ISHC and Purdue University by authorizing cooperation among ISHC, Purdue's engineering school, and counties—both in developing new improvement and maintenance techniques and in disseminating information through joint road meetings throughout the state.[141]

The Roosevelt administration released a huge federal highway improvement appropriation that allocated $10 million to Indiana in 1934 and initiated a highway program for cities. The National Recovery money salvaged the state's construction program, which was severely depleted when $3 million was diverted to the counties for a relief-related construction project to widen road shoulders on 1,000 miles of state highways. While half of the federal dollars went to highway construction, most of the other half—44 percent—was dedicated to cities with 3,500-plus population. The new urban funding pushed ISHC into a hurry-up municipal program where none had previously existed. Engineers pointed out that municipal work required more survey, planning, and detailed design than rural work. The new work for 49 cities included "projects of tremendous and far-reaching importance," such as street widening, resurfacing, realignment, construction of new bridges and widening of old ones, and replacement of grade crossings with separations.[142]

PWA grants and grade-separation dollars funded more projects.[143] Even before the grade separation money was allocated, and on the basis of "rumors from Washington," ISHC expanded its drafting staff.[144] ISHC supervisors went to West Lafayette where they oversaw the work of Purdue University students using school facilities to prepare plans for the state. The money from the Emergency Relief Appropriation Act of 1935 arrived late in the year, during the 1936 ISHC fiscal year, but the push to prepare plans allowed ISHC to move ahead quickly with contracts.[145] The federal grade-separation funds were important because railroads, being private companies, sank into financial trouble during the Depression and very few new grade separations were constructed. Some railroads had simply walked away from existing agreements for grade separation projects.[146]

From the mid-1930s to the advent of World War II in 1941, ISHC continued to rely on the increased flow of federal funds from the New Deal programs while expressing occasional concern about their continuance and the availability of state dollars.[147] During the same period ISHC focused on highway and bridge issues that would become increasingly important in the coming years: testing, safety, transportation planning, and divided highways.

(b) ISHC testing facilities

ISHC reported that its testing facilities, as of 1934, were "the weakest point in the entire set-up of the Indiana State Highway organization." The state ran the risk of allowing "inferior materials" into highway and bridge projects.[148] Despite the acknowledgment, nothing was done. By this time, ISHC was carrying out cooperative investigations with BPR, the Highway Research Board (HRB), and the American Association of State Highway Officials (AASHO). The BPR "severely criticized" the "congested quarters and incomplete facilities" in 1935.[149] Thanks to a PWA grant, ISHC was able to begin construction on a new testing lab the next year.[150] Completed in 1937, ISHC declared the new lab "one of the most efficient laboratories of its kind in the United States."[151]

ISHC test department staff helped establish the Joint Highway-Research Project for experimental work at Purdue.[152] Begun in 1936 and authorized by the 1937 legislature, the program's advisory committee was comprised of three ISHC representatives and three Purdue engineering professors. It was located at the university's Engineering Experiment Station in West Lafayette. The mission involved both testing and education, including the Annual Road School and joint road meetings throughout the state with county and state highway officials, as well as public education meetings.[153] The project reflected concern with the increasing mileage on the state system, which doubled in the 1930s from 5,065 miles in 1929 to 10,172 miles in 1939, as well as faster, heavier traffic, and with new, expensive construction techniques, such as dual-lane highways. The project also involved itself with issues of traffic safety and advanced engineering and planning. As a 1940 report stated, "highway engineering may be compared with large business enterprises both in extent and personnel requirements," which meant professional highway engineers and "technical experts and executives" such as those developed by the project. "Research Pays Dividends" was the slogan on a project chart titled "Indiana's Unique Solution," which favorably compared the ISHC's financial investment in research with that of "progressive industries." A roster of advisors and staff highlighted their academic credentials and technical experience along with their professional affiliations with AASHO, HRB, American Society of Civil Engineers (ASCE), American Concrete Institute (ACI), and others.[154]

(c) Traffic safety

While traffic safety had been a concern for years, by the mid-1930s the ISHC was viewing the growing number of automobile accidents with increasing alarm. The percentage of fatalities per accident was particularly disturbing, having increased 80 percent in 1936. Engineers, who hadn't yet imagined modern crash-resistant railings and other barriers, pondered their inability to prevent "freak accidents." What could the ISHC do about such incidents as a "driver [who] cupped his hand over a match to light a cigarette....[and] a second later he was dead, his car having crashed through a telephone pole into a brick building during the moment his eyes left the road"?[155]

If some accidents seemed unpreventable, ISHC engineers were recognizing speed as "the heavy contributing factor to this appalling slaughter."[156] A safety-related project that looked to the future was the design and construction of "divided lane or dual highways." ISHC began building divided lane highways in 1935-36 on heavily traveled roads where reconstruction became necessary. The idea was to build safety into the highway design. The first divided lane highway in the state was a section of U.S. 30 between Schererville and Deep River. Plans were prepared for "an extensive development of divided lane highways in Indiana in years to come."[157] Within a year work was begun on a second divided highway on U.S. 40 between Putnamville and a point east of Mount Meridian.[158] More projects were scheduled for U.S. 24, U.S. 40, and U.S. 50.[159]

The divided lane highway was a major element in a range of safety features that were being increasingly employed in highway design and construction, including widened berms, shallow and rounded ditches, flat slopes, longer sight distances, improvements in alignment, and the continuation of guardrail installations at hazardous points.[160] Bridge design was being considered along the same lines. In 1934-35 ISHC reported that "we have demonstrated that bridges can be built on alignment curves with super elevation, as well as vertical curves, without sacrifice of careful workmanship and pleasing lines."[161]

(d) ISHC survey and planning

In 1932, faced with the increasing numbers of local roads being transferred to the state system, ISHC felt the need to approach road acquisition in a more orderly fashion. ISHC requested and received the cooperation and support of BPR for a survey. The survey was largely a traffic-flow and traffic-density study. While other states had gathered similar data, Indiana was the first state to conduct its own analysis instead of sending the data to Washington for processing.[162]

The Indiana Traffic Survey, completed in 1933, according to ISHC, was "one of the most comprehensive surveys ever made in the United States to gather traffic data."[163] ISHC reported that Indiana had one of the most dense road systems anywhere, with 2.14 miles of road for each square mile in the state, which was exceeded only by Connecticut (2.52) and Massachusetts (2.34). In addition, Indiana had more miles of "surfaced" roads than any state.[164] The analysis showed that 64 percent of all rural highway travel was on the state system, which was 11 percent of all Indiana highways. That meant that about 36 percent of travel was on the remaining 89 percent of highways that were not state owned. The data in the survey would allow the state "to determine more intelligently where roads should be built and which links are most important in completing the highway system."[165] The survey represented a significant effort by ISHC to engage in highway planning and move beyond the piecemeal efforts of earlier years.

The State-Wide Planning Survey division, which developed into ISHC's "fact-finding and planning division" by 1940, was a logical outgrowth of the 1933 Indiana Traffic Survey.[166] It was initiated in 1936 in cooperation with BPR, which had been interested in planning since the beginning of the federal-aid program and promoted major planning efforts in the 1930s.[167] The Survey division's intent was to create an inventory of all road facilities of the state, a traffic volume and classification determination on all roads, and a financial and industrial study. Overall, the division's work involved a comprehensive set of studies and fact-finding projects "designed to enable the highway administrators to prepare broad rational highway plans and programs," based on sound, current information. The information was also used for planning the expenditures of federal-aid funds. Touting their modern approach to survey and comprehensive analysis, ISHC reported that the data was recorded on a punched-card system for mechanical tabulation.[168]

The ISHC planning efforts would soon prove useful because World War II, faintly visible on the horizon of 1939 and 1940, would become an all-encompassing reality for Hoosiers and America by the end of 1941. Planning would be among the few tasks ISHC could support during the war.

(3) Indiana highways and ISHC during World War II

With the advent of war in Europe—even before United States involvement in 1941—President Roosevelt backed a serious reduction in "nonessential" highway funding. Very quickly the only roads and bridges considered for construction or improvement were those related to wartime needs, such as military facilities and defense plants. The Defense Highway Act of 1941 provided federal dollars for access roads to facilities and strategic highways for a general national defense network.[169]

ISHC recognized that the needs of national defense increased the responsibility of the state to the federal government. Because of Indiana's central location, it had numerous defense plants and industries, as well as military bases. It also had considerable state highway system mileage on the newly designated strategic highway network. The need to upgrade access roads, including the reconstruction of inadequate bridges, required experienced engineers who were increasingly in short supply due to the war.[170]

Following the attack on Pearl Harbor on December 7, 1941, ISHC became totally involved in the war effort. Most highway contracts of any size were confined to the 1,143 miles of state highways designated as part of the strategic network by the BPR under the direction of the War Department. The strategic highways included all roads that the military felt to be of importance for the movement of troops and war materials. For work on the strategic system, the federal government paid 75 percent of the cost instead of the customary 50 percent. Roads that were not on the existing state system prior to the war were covered at 100 percent.[171]

Important access roads were constructed to the Jefferson Proving Ground near Madison, the Indiana Ordnance and the Hoosier Plants near Charlestown, the Fort Wayne Airport, the Kingsbury Ordnance Plant near LaPorte, and Fort Benjamin Harrison outside of Indianapolis. In addition, access roads were authorized for Delco Remy Division of General Motors and the Studebaker plants at Fort Wayne and South Bend.[172] The military also closed some roads, requiring new construction for non-military traffic. For example, a highway was relocated around the Burns City Naval Ordnance Plant. The work included both roads and bridges.[173]

Suddenly shortages of labor and materials were acute. Steel for bridges and reinforcing in concrete pavements was scarce. To conserve steel, the concrete in pavements and bridges was made thicker and bridges were constructed as “gravity-type concrete arches.” Wood was substituted for steel wherever possible and wood culverts were built instead of concrete. Guardrails using flexible steel plate or wire-rope were dropped from projects. Because of the shortages, contractors quit bidding on projects, and soon there was even a scarcity of contractors for highway work as many shifted to defense contracting.[174]

By the mid-point of the war, ISHC was deep into postwar planning and had begun a 10-year plan for future improvements to roads and bridges. The cost was estimated at $160 million, with $34 million earmarked for almost 900 bridge projects. ISHC estimated that $10 million in contracts could be let within 30 days of the war’s end, helping to rebuild roads deteriorated by wartime traffic while helping to put returning veterans back to work.[175] The final war years before V-E and V-J Days in 1945 were spent in holding actions and a planning posture. Construction was limited to remaining projects around defense and military facilities. The reduced amount of work was appropriate, ISHC staff felt, since there was such a shortage of “engineers and other technical men.” “Conservation” was the “one word to describe the activities of the commission” in 1944. Meanwhile, planning—including financial planning—continued for the “giant road and bridge construction program that is proposed after the war.”[176]

As the war ended in 1945, ISHC prepared to implement its postwar highway program. “The State Highway Commission of Indiana is now in the position of vigorously instituting a program for the rehabilitation of your state highway system to meet the rapidly increasing needs of postwar peacetime traffic,” it announced. During the war years work had been held to a “bare minimum,” but “now every effort must be centered” on the postwar program “as quickly as available funds will permit.” Every department was getting itself ready. The Right-of-Way Department was “securing right-of-way for postwar projects” and the Road and Bridge Department was ”now vitally concerned with the program for postwar construction.” [177]

The ISHC began preparing the public for “a program [that] will require a vast sum of money”—as much as $53 million a year for the next two or three years. It was a “startlingly high figure” for a “gigantic roads program.” But, as described in their annual report, the ISHC had become “a non-combatant victim of the war,” a victim with “pernicious anemia,” and now “the doctor must be paid.”[178]

G. Post-World War II (1945 to 1965)

During World War II, ISHC’s road and bridge activities were severely restricted by the defense-related needs of the nation and by war-related shortages of personnel, equipment, and supplies. As construction was restricted to roads and bridges on the strategic highway network, ISHC devoted staff and resources to major planning efforts for the postwar period. While the commission needed to reestablish itself after the wartime depletion of resources, it was energized by a vision of future highway growth and expansion and was eager to see its planning efforts come to fruition. Federal funding for highways increased following the war, leading to the expansion of primary roads throughout the country and eventually the Interstate Highway System, which had its origins in the 1944 Federal-Aid Act. By the late 1950s, the establishment of the interstate would dramatically alter the design and funding of the state highway system beyond what even the ISHC's wartime planners had envisioned.

(1) Federal-Aid Highway Act of 1944

The Federal-Aid Highway Act of 1944 established the basis for federal-aid bills until 1956 and funding for the interstate system. It expanded the federal-aid primary road system, encompassing roads that states had designated as main transportation routes of the national highway system. The act also provided new funding for construction of secondary roads (also known as feeder roads, which included farm-to-market roads, rural free delivery routes, and public school bus routes) and urban highways in areas with a population over 5,000. Previous federal aid focused largely on primary roads and restricted the miles of secondary roads that could be improved with federal funds. The 1944 Federal-Aid Highway Act was the first time funding was provided for urban and secondary highways, without mileage limitations.[179]

The act provided $500 million in nationwide funding over a three-year period, with $225 million allocated to primary roads, $150 million to secondary roads, and $125 million to urban roads. Although a large sum, the money proved to be somewhat limited when distributed among all states. Funding for urban highways was distributed by population and for rural highways it was distributed to the states in proportion to rural population, geographic area, and post-road mileage (roads along postal routes). States were required to match federal allotments on a 50/50 basis. Indiana received about $36 million, including $16 million for primary roads, $11 million for secondary roads, and $9 million for urban roads.[180]

The 1944 act also allowed states to use 10 percent of their funds to eliminate highway-railway crossing hazards on the federal-aid system. Where vehicular and railroad traffic intersected on the same grade level, the intersection was termed an at-grade crossing. Under this program, hazardous at-grade crossings were replaced by new grade-separation structures, designed to elevate one, either roadway or railroad, over the other.

Despite the intentions of Congress, the 1944 act did not solve the nation's transportation problems, in part because it did not anticipate the dramatically increased automobile ownership and truck use in the postwar era. This unexpected flood of cars and trucks caused congestion in urban areas, increased pressure on the overall transportation network, and created greater maintenance costs for roads and bridges. The act did, however, update and expand the federal-aid process and create a framework for highway funding and planning at the state level.[181]

(2) ISHC in the postwar era

ISHC launched a massive survey and inventory of the state highway system in 1947. The study was designed, in part, to support the request for what ISHC had determined was "a vast sum of money, far more than has ever been spent on highways in the past." The existing Motor Vehicle Highway Account—the fund of gas tax and license fee revenues—plus federal-aid allocations, would be inadequate, the commission projected. The survey would include a detailed inspection of every mile of state road, listing type of construction, condition of surface, condition of all bridges and approaches, number of intersections, grade separations, and railroad crossings. The report would "be valuable to those who have the responsibility for determining the amount of necessary funds to be collected for road building."[182]

The resulting report, *Highways of Indiana,* published in 1948, was aimed at the general public rather than a narrow technical or legislative readership. It may have been the first comprehensive review of the state highway commission for a wide, general audience since the beginning of ISHC. In the language of the report, its mission was "to bring the complete story of the state highway system to the citizens of Indiana" so they would know the facts, because "only by knowing the facts....can the citizens of the state be sufficiently informed to express their will to their legislators…."[183]

It opened with three chapters outlining the history of roads in Indiana, from eighteenth-century wilderness trails, through the early years of late nineteenth- and early twentieth-century road building, the automobile, the development of the ISHC, and ending with the current postwar highway situation.[184] The overview offered a vision of progress leading to the present. The question for the present, for Indiana citizens and taxpayers in 1948, was: Where do we go from here? The answer would come from looking at the facts, because—as a chapter title made clear—"Facts Determine Needs."[185] In other words, the professionals had done the research and would present the situation to the public without politics or bias.

What were the reported facts in 1948? The situation emerges from the topic headings in the report: "Rising Trend of [Motor Vehicle] Registrations," "Heavy Trucks on Increase," "Narrow Right of Way," "Narrow Pavements are Bottlenecks," "Narrow and Unsafe Bridges," "Unprotected Railroad Grade Crossings," "Rough Road Surface," "Steep Grades," and "Sharp Turns"—to list some examples. ISHC engineers had prepared plans to deal with all of these issues, which were seen in terms of highway safety and accident reduction, but plans "must be translated into steel and concrete—into bridges, highways, and grade separations." This could happen only when "adequate finances are provided."[186] The problems identified were not unique to Indiana. Other states experienced similar situations. Moreover, postwar inflation was eroding the dollar and overall highway construction and maintenance costs were escalating.[187]

ISHC proposed an 11-year program, from 1950 through 1960, that would bring all roads and bridges up to a "minimum tolerable standard" (undefined in the report), implement needed safety measures, produce long-range construction plans to keep pace with traffic predictions, reconstruct state routes in cities, and match all available federal-aid funds. The price tag was $67.5 million annually for the minimum "necessary improvements," or $89.5 million for "desirable improvements." Inaction would result in more accidents, more traffic code restrictions, "progressively greater inconvenience" for the traveling public, and a steady rise in maintenance costs that would have economic consequences beyond the highway system.[188]

Whatever the consequences and results of this 1948 report, they are not apparent in the annual ISHC expenditures. From 1949 to 1956, when federal aid for the Interstate Highway System altered budgets dramatically for all states, the ISHC annual expenditures increased in modest amounts and never did they top even the estimated minimum of $67.5 million. The 11-year plan is never mentioned in subsequent ISHC annual reports, which continue to note the need for more money for highways and bridges. The study of highway needs appears to have been repeated in 1957 and 1958, although with considerably less appeal for the public to lobby their legislators for funding increases. These subsequent reports, while including similar rhetoric about the value of improved highways and bridges, the projected costs, and the consequences of neglect, were produced by research staff at Purdue University and have the appearance of internal, academic studies. The 1958 "Final Report: A Study of Highway Needs in Indiana," which is more substantial than the 1957 "technical paper," projected a 15-year plan and noted the "dismal prospect" of an inadequately funded highway system.[189]

(3) Interstate Highway System[190]

The Federal-Aid Highway Acts of 1950, 1952, and 1954 were less consequential overall than those of 1944 and 1956, both of which played larger roles in the creation of the interstate system. The acts of the early 1950s did move the focus of federal spending for construction more toward the cities. A significant element in that period was the Korean War, which not only reduced federal highway spending but helped generate a steel shortage. At the same time, however, that war also provided the opportunity for interstate supporters to again argue, as in 1944, for a highway system based on the needs of national defense. This, in turn, led to reasons to argue for increased federal highway funding.[191] This discussion largely evaporated when the interstate system and its massive new funding mechanism emerged in 1956.

The Federal-Aid Highway Act of 1956 significantly overshadowed other highway acts of the early 1950s. This act not only increased federal appropriations to states for primary, secondary, and urban highway construction, it more importantly made the first substantial appropriations for construction of the Interstate Highway System. The act also brought uniformity to nationwide road-building efforts and included a provision requiring the BPR to work with the AASHO to develop design standards to accommodate traffic forecasts through 1975. Standards were meant to ensure national uniformity of design, provide for full control of road access, and eliminate at-grade crossings.[192]

The origins of the federal interstate system of highways are found in the military interest in road development that began in the 1920s, when roads of prime military importance began to be identified. A 1939 BPR report advocated a special system of interregional highways and was side-tracked almost immediately by World War II as funds were diverted to the war effort. It was not until 1941 that a defense act was passed that provided specific funds for constructing such roads, including freeways.[193] In that year, President Roosevelt appointed the National Interregional Highway Committee to study the manpower and industrial capacity that would be available at the end of the war.[194] The committee recommended the establishment of the National System of Interstate and Defense Highways the same year that the 1944 Federal-Aid Highway Act was enacted. The 1944 act explicitly called for a national system of interstate highways, but did not include funding.[195] Construction of interstate highways was initially justified as a defense system for moving military vehicles and evacuating civilians. Defense requirements called for the interstate system's geometry and structures to accommodate and aid the movement of large military equipment.[196] The system of highways was to connect principal metropolitan areas, cities, and industrial centers by direct routes and to connect with routes of continental importance in Canada and Mexico. States submitted recommendations of routes to be included in the interstate system. However, construction moved slowly due to high standards and limited federal aid.[197]

The modern era of the interstate began in the early 1950s as lobby groups began to encourage a political vision of a nationwide road network.[198] In 1952 the Federal-Aid Highway Act included the first authorized federal funds specifically for interstate construction, a nominal $25 million nationally.[199] The federal share of interstate construction increased from 50 to 60 percent with the passage of the Federal-Aid Highway Act of 1954.[200]

President Eisenhower, recognizing the importance of a national highway system for defense, appointed a committee to study American highway needs in 1954 at the height of the Cold War. The committee advised Eisenhower that an interstate system was needed. New York's "master builder," Robert Moses, was also involved in the development of the system; he had pushed for the large scope of the project through consultations with Eisenhower assistant Sherman Adams and with General Lucius D. Clay, chairman of a key presidential committee studying highways.[201]

In 1956 both the Federal-Aid Highway Act, which got the interstate program underway, and the Highway Revenue Act, which provided the funding for the program, were passed. The acts expanded the interstate system to 41,000 miles and provided allocations for 90 percent of construction costs, with states responsible only for the remaining 10 percent, a major departure from earlier 50/50 matches. The entire interstate system was anticipated to cost more than $27 billion nationwide. In order to finance construction, the legislation created the Highway Trust Fund, which was supported by an increased federal tax on gas and diesel fuel. The 1956 legislation also authorized an initial 13-year construction period for interstate highways, which would eventually be extended as states faced routing and funding difficulties.[202]

Almost from the beginning, the experience of the interstate changed the perception of highway travel among transportation professionals and citizens alike. Both groups looked to the Interstate System's innovative "expressway standards" as the new basis for highway design at the state, county, and city level.[203] Innovations included such design elements as wide, four-lane, divided highways, with limited access, minimum grades, and wide curves. Increased federal funding during the period from 1947 to 1965 also meant that new bridges were needed to accommodate new and improved secondary roads, urban expressways, and the interstate.

In 1956 ISHC (which was renamed the State Highway Department of Indiana from 1953 to 1961[204]) immediately began planning for what it termed "a gigantic program to improve a network of roads across Indiana"—the Interstate System. Indiana's share of the Interstate System was approximately 1,065 miles at the beginning. The state's initial appropriation for fiscal year 1957 was $40.3 million. Already the Metropolitan Area Traffic Survey section of ISHC was spending their time in preparation for the interstate. Since the new system would involve limited-access highways, there was additional work in cataloguing existing private and public driveway entrances and approaches. The Interstate was apparently a new and different situation, because the 1956 annual report concluded that "the Department has many perplexing problems brought before them and there have been some special problems which have been hard to decide."[205]

By 1959 ISHC found that the increased volume of work on the interstate system was affecting all departments. Not only had ISHC used its own engineers and draftsmen, but now was going outside the agency to contract with consulting engineering companies "in order to expedite surveys and plans for this gigantic program." The consulting engineers prepared plans for both highways and bridges. ISHC also went outside the agency for public comment on its projects. The 1956 act included a provision that, for the first time, required public hearings for certain federal-aid projects that generated citizen interest, including complaints. Within a few years the process had become institutionalized by ISHC, which now highlighted public hearings on highway projects as the American way of running a responsible government agency.[206]

As ISHC completed the first half of the 1960s it was preoccupied with two large areas: planning and the Interstate System. Regular long-range planning at the state level was now "mandatory" for an agency that was a "$150,000,000 a year business." Much of the need for longer-term planning was driven by the Interstate Highway System. Building a section of interstate was a four- to five-year process, ISHC pointed out, while their agency planning process was in two-year increments. ISHC went to five-year plans, the first of which was approved in 1962. Repeating a long-held view of transportation planning, ISHC declared that "roads can now be built by priority based on scientifically measured need rather than on the basis of relieving the pressures on the commission."[207]

Thanks to the Federal-Aid Highway Act of 1962, planning was extended to urban areas, which were now required to prepare transportation plans in order to receive federal funding. The program was called the "3-C" planning process, for "continuing, cooperative, and comprehensive" urban planning. When combined with existing state and local planning efforts, it was called "partnership planning" by ISHC, which offered its urban planning specialists to help cities and counties create "cooperative committees" to assess local highway needs and prepare 15- to 20-year road and street programs.[208]

The interstate became the major preoccupation of ISHC in the early 1960s. Because of its size, the enormous interstate effort increasingly affected everything ISHC did. When ISHC introduced the "Story of a Road" in its 1963 annual report, outlining the many steps in the complex construction of a modern highway, it was describing the process of building the interstate. "The road you use today," ISHC told Indiana taxpayers, "involves planners, designers, draftsmen, engineers, accountants, lawyers, soil and materials testers, rodders, marker men, stenographers, statisticians, land agents, chemists, clerks, typists, and maintenance men."[209]

The financial impact of the interstate undertaking is obvious in ISHC's annual budgets after 1956, when major interstate funding was authorized. In the year between 1958 and 1959 the agency's total annual disbursements shot up 63 percent, from $64.3 million to $104.7 million. The following year, 1960, it jumped to $136.8 million. By 1965 the annual ISHC disbursement had reached

$172.1 million and the interstate was far from its projected completion date of 1972. Only 18 miles of Indiana's planned 1,120-mile portion of the nation's interstate were open in 1960. The program was soon accelerated. By 1963 the mileage had grown to 198, not counting the 157-mile Indiana Toll Road, which was incorporated into the system. Almost lost in the flood of interstate statistics was a $2-million bridge-widening program, authorized by ISHC in 1962-63 and considered "unprecedented" in scope.[210]

Among the items that magnified the interstate's significance for Indiana was the state's central location in east-west traffic and, in turn, the capital city's central location within the state. Now Indianapolis became "Crossroads USA" and "America's Busiest Intersection," where seven interstate highways converged like spokes on a wheel. ISHC boasted that seven was one more interstate highway than any other city would claim. The Commission's 1963 annual report stated that three routes—I-65, I-70, and I-74—crossed through the city, creating, in effect, six highways converging on Indianapolis, while another—I-69—terminated there, for the total of seven. On top of that was I-465 beltway that cut across and linked all seven highways. Beginning with the National Road and continuing through the Lincoln Highway and the east-west toll roads, Indiana has been vital to interstate commerce and travel. The interstate system built upon Indiana's transportation origins and expanded it beyond anything the earlier road builders could possibly have imagined.[211]

3. Bridge Engineering and Construction

Bridges serve as critical links in the road networks discussed in Section 2, providing crossings over waterways, on primary and secondary roads, and grade separations over railroad tracks and highways. As road systems were upgraded, constructed, and expanded, bridges were built, reconstructed, or replaced to complete these networks. Design and construction of bridges nationwide, and in Indiana, was first accomplished in a decentralized manner by individuals, local and county governments and private road-building ventures. However, the advent of the automobile and its increased usage through the early twentieth century affected public attitudes towards road conditions and influenced a Progressive Era movement towards centralized and standardized road and bridge design.

While there are numerous accessible sources on national and state-mandated bridge design, the role of the county or local government is often overshadowed. However, of the 6,333 extant bridges built prior to 1966 in Indiana, over 70 percent are under the jurisdiction of counties.[212] Nonetheless, state, national, and federal agencies influenced Indiana county bridge design after 1920 by administering monies and establishing and disseminating standards for bridge design and construction.

This section begins with early bridge-building trends, including entrepreneurial design and the consolidation and standardization of bridge design. The role of governmental agencies and professional organizations and their influence on Indiana county and state bridge design is also considered. ISHC's bridge-building program, including its use of standard plans, efforts to construct economical structures, and collaboration with university research institutions for the purpose of identifying new materials and methods of construction is addressed. Moreover, material and engineering advancements that influenced the evolution of bridge design in Indiana from the 1830s through 1965 are considered according to bridge-building material and bridge type. Finally, this section discusses bridge design, aesthetics, and notable bridge engineers, designers, and builders.

A. Bridge building in Indiana

Bridge building in the nineteenth and early twentieth century may be characterized by two chronologically ordered trends—private design and experimentation sometimes protected by the patent system and the consolidation and standardization of bridge design. Although bridge building in timber and stone was conducted by individuals and private companies, the relative decline of these materials, as used for bridges, preceded the widespread movement towards consolidation and standardization in manufacturing industries, including bridge fabrication and construction. The two related trends of private experimentation and consolidation are first witnessed in the history of metal bridge building. Concrete bridge design mimics this evolutionary pattern, albeit, on a different chronology and influenced by different historical circumstances. Nonetheless, bridge building in both metal and concrete in Indiana and the United States was first guided by private, entrepreneurial design before being centralized and standardized. This section introduces these trends.

(1) Private experimentation and the American patent system

Before the creation of federal, national, and state agencies to oversee road and bridge construction, bridge building in Indiana was accomplished under county jurisdiction. Individual bridge builders, fabricating companies, county surveyors or engineers were contracted by the local government to design bridges. Private design and entrepreneurial pursuits were encouraged. Although limited information on Indiana bridges built before 1850 is available, due to the high cost of construction and maintenance, the earliest bridges were generally constructed by private companies as toll bridges under the direction of county commissioners. References to bridge construction before the 1830s include those along the Michigan Road and National Road, with limited construction along state roads. Segments of roads were often constructed by local contractors or farmers under contracts, which resulted in many of the bridges also being erected by local builders.[213]

Builders of stone arches, timber-covered bridges, and metal trusses alike erected bridge configurations according to previous experience and practice with available materials. Bridge types were often adopted according to the diffusion of established types from the east coast of the United States, and adapted by local bridge-building entrepreneurs. For example, J.J. Daniels, a prominent Indiana covered-bridge builder, often experimented with the established Burr Arch truss bridge design. His experiments include the insertion of an iron plate between the masonry abutment and lower truss member to prevent the timber from absorbing moisture and rapidly decaying.[214] Experimentation, such as this, in design, fabrication, and erection proved essential to increasing profitability by enhancing efficiency and economy of material. Moreover, such innovation could be legally protected by American patent law, if a patent was obtained.

The American patent system protects empirical innovation by granting patents for a limited term of 17 years. A patent, in legal terms, is the right "to exclude others from making, using, or selling," the invention; thus patents secure an initial profit for the inventor but do not permanently preclude free public use of the invention. The American patent system is based on empirical knowledge, which is based on practice and experimentation, rather than theory. Therefore, application for a patent does not require theoretical or scientific justification for the device, but it does mandate that proof of the workability and functionality of the invention be submitted. The first version of American patent law went into effect on April 10, 1790, and the first bridge patent was secured in 1797 by Charles W. Peale for a timber truss.[215] Bridge design in the United States and Indiana was generally protected by the patent system through the 1910s, if inventors or designers submitted applications for patents to secure their intellectual property rights.

By 1880 the number of bridge engineers and manufacturers proliferated as many new firms were established. In general, the 1890s witnessed a decline of metal truss design experimentation and an increase in experimentation with production. As such, metal bridge-fabricating companies submitted and secured fewer patent applications during the 1890s, but facilitated more efficient methods of manufacturing established truss patterns.[216] For example, the Lafayette Bridge Company of Lafayette, Indiana, began by building a large fabricating plant with state-of-the-art machinery in 1891. Rather than capitalize on design experimentation and patent application, the Lafayette Bridge

Company, like many Indiana bridge-building firms of the 1890s, focused on fabricating efficient, simple bridges with new manufacturing techniques.[217]

From 1890 through 1915, engineers who worked in concrete frequently sought patents for various bridge components such as concrete reinforcing methods and specific bridge type patterns. For example, Joseph Melan received an American patent for his concrete reinforcing system in 1893, and Indiana's Daniel B. Luten was granted his first patent in 1900. Luten maintained the largest number and widest range of patents relating to concrete bridge design in the United States; by 1916 he had over 40 patents. Luten believed he created the best and most efficient bridge for a particular site by using design elements he had developed through practice and which he patented. Luten is discussed in more detail in Section 3B. Although concrete bridge designers, like Luten, followed a traditional and established method of securing and protecting their intellectual property, court cases between 1915 and 1920 challenged the validity of bridge patents. The courts of Iowa and Colorado led the way by invalidating bridge patents of engineers like Luten and Edwin Thatcher, another designer of reinforced concrete bridges. The courts claimed that patents protected applications of engineering knowledge rather than manifestations of "inventive genius." The loss of patent protection for bridge designers signaled the movement away from private design and towards centralized control over bridge building and professionalized engineering.[218]

(2) Consolidation and standardization

During the late nineteenth century, metal bridge-fabricating companies, influenced by industrial expansion, focused on efficiently manufacturing established truss patterns. Companies invested less money into developing new, innovative designs and submitted fewer patent applications. Moreover, competition among bridge-building firms increased as steel manufacturers worked to gain control of the market by limiting smaller companies' access to steel. As steel manufacturers took control of and consolidated bridge-building firms, local bridge manufacturers found it more difficult to obtain materials. For example, when the American Bridge Company—a subsidiary of U.S. Steel Corporation—purchased 24 bridge-building firms across the United States, much of the local competition came to a halt. A dominant force in bridge building, the American Bridge Company began operations in Indiana in 1900, with the purchase of Lafayette Bridge Company. Moreover, American Bridge Company developed a Gary, Indiana, steel plant from 1909-11, to manufacture most of its bridge orders. As part of their industrial consolidation plan, U.S. Steel Corporation expanded both vertically and horizontally, incorporating numerous bridge-building companies and related processes such as mining and metal fabrication. Consolidation, in the context of metal bridge building, was provided by private companies who sought to dominate the market for steel. Standardization of metal bridge building was related to the fabrication of identical, interchangeable parts, and thus is critically connected to the popularization of mass production techniques.[219]

During the early twentieth century, federal and state governments began to consolidate road and bridge-building programs; this was signaled, in part, by the invalidation of reinforced concrete bridge-related patents. Indiana's Daniel Luten, whose patents had been invalidated, decreed standardization of design by government agencies as the institutionalized inefficiency of bureaucrats. Luten believed that centralized government control was rigid and costly while local control retained flexibility in the marketplace.[220]

However, Luten represented the end of an era. The new wave came in the person of Thomas H. MacDonald and the Bureau of Public Roads, the federal agency overseeing highway and bridge design and construction. As far as MacDonald and the BPR were concerned, Daniel Luten represented the less-admirable side of entrepreneurial activity which exploited the politics of local governments to secure contracts for untested designs and fill private wallets. Luten's version of bridge design and construction, in this view, put private interests above public interests and, especially, public tax dollars and public safety. In MacDonald's view, Luten's method left this vulnerable business of bridge design to chance and chance was not good enough for the public.[221]

Although the two perspectives of bridge design and construction were played out in various states and localities in the first decades of the twentieth century, things took an official shift in the direction of government control with the passage of the Federal-Aid Highway Act of 1916. The act predicated that federal funds for road improvements be administered by state highway departments whose actions would be guided by federal standards and guidelines. Indiana, the last state to create a highway commission, was compelled to come on board with the national system. The only option was that of centralized state and national control. While federal involvement in state highway and bridge building greatly reduced the market of work for consulting engineers, cities and counties, who had local monies available, could provide a small arena for private design competition. However, Indiana state legislation passed in 1917 and 1919 extended state influence over bridge building. If 50 or more electors petitioned or county officials volunteered, then specifications and plans for county road or bridge projects expected to total more than $2,000 would be submitted to ISHC. After ISHC was involved, the county was required to award the contract based on the ISHC-approved specifications and plans. During the 1920s and 1930s Indiana-based engineers such as Daniel Luten, William S. Moore, and Charles McAnlis worked as consulting and designing engineers in a dwindling bridge market that had been cut in half by ISHC.[222] The system of private, entrepreneurial bridge design and construction was ending.

B. Influence of national design standards

If the nineteenth century celebrated individualism and the individual, the twentieth century swung the pendulum the other way and became the era of the corporation, the collective, the agency, the organization, and the state. One need not become entangled in socio-political theorizing about individualism versus collectivization to appreciate some of the effects of the change.

In the world of highways and bridges, the pendulum swing manifested itself in the move away from locally controlled, private, or entrepreneurial bridge design and towards consolidated, government-controlled and mandated design. The mechanism for enforcing the change became not only law, but funding. Bridges are expensive undertakings—increasingly too expensive for small, local units of government. As federal and state funding became available and, increasingly, indispensable for bridges, the funding agency could control the design and construction process: no design approval meant no funding for construction.

A further corollary of the government control of bridge design was the sentiment growing out of the Progressive Era that individual, entrepreneurial design and construction processes were vulnerable to political influences and, worse, corruption. Centralized control came to be viewed as being above politics because it was based on rational examinations of need, analyzed by scientists and other experts. These non-partisan civil servants were interested only in facts, not power and money. An unemotional examination of the facts of a highway and bridge situation would result in an appropriate treatment. In the view of a growing segment of the American public, rationality in the face of issues of money and public safety became more desirable than the risks of experimentation. The possibility of great new inventions was always balanced by the possibility of disastrous failures, possibly tainted by greed and corruption. The rewards of experimentation were, on balance, not worth the risks. A slower, but steadier, rational process was more desirable.

In accordance with this shift towards centralized control and rational design, two national organizations emerged to play a prominent role in setting and disseminating design standards for bridge construction—BPR and AASHO. BPR set the tone for state highway and bridge development by serving as a model of professional planning. In particular, BPR's engineers portrayed themselves as unbiased, apolitical, and guided by a scientific approach to bridge design. AASHO, the predecessor to the American Association of State Highway and Transportation Officials (AASHTO), also promoted professional planning and national standards which were designed to be adopted by state highway departments.

Plans and guidance developed by BPR and professional transportation organizations like AASHO were instrumental in setting federal transportation policy and disseminating information regarding new materials and technology, standard bridge designs, and best practices to state departments of transportation. National design standards, plans, and specifications were frequently adopted by state departments of transportation, including Indiana, and they assisted the state in efficiently and economically implementing bridge planning and construction. In the post-World War II period, the technical approach of BPR and AASHO culminated in the 1956 interstate system, which put in place a new and different set of highway design criteria and standards that seemed appropriate for unprecedented growth in highway travel in the 10 years following World War II. An overview of activities of BPR and AASHO is presented to provide a national context for bridge-building activities of ISHC during this period, which was undoubtedly influenced by these national organizations.

(1) Office of Road Inquiry/Bureau of Public Roads

In 1895 the ORI was established in the USDA to promote the Good Roads Movement, advocate technical expertise, prepare county road maps, and provide information on road construction through the circulation of bulletins, technical testing of materials, and the construction of demonstration roads. The agency, which was the predecessor to BPR, believed that research and a scientific approach to highway construction would provide guidance to improve the often miserable road conditions of the early twentieth century, including inadequate bridges. In 1910 the now renamed OPR established a Division of Bridge and Culvert Engineering that began to construct demonstration bridges, publish bridge construction information, and prepare standard specifications and plans for various bridge types for state and local use.[223]

OPR initially faced difficulties in receiving public support because the centralization of design at the state and federal level challenged the current practice of local design. Through programs such as offering “free” bridge design to local governments in the 1910s, OPR was at the center of the conflict between local versus state and federal control of road and bridge design. Entrepreneurial engineers who promoted their own designs and local units of government who realized that the bridge designs of BPR could be more costly were at odds with this new agency.[224]

With the passage of the Federal-Aid Act of 1916, this federal agency was responsible for administering the matching grants to the states and required states to follow federal standards and guidelines, including for bridge construction.[225] Compliance with the provisions of the 1916 act was quickly seen in Indiana following the establishment of the ISHC. ISHC’s chief engineer reported in the 1919 biennial report that “all (state) highway work has been standardized to a great extent to comply with the requirements of the U.S. Bureau of Public Roads” and that the BPR had approved the state’s standard plans for culverts.[226]

To disseminate research, BPR began the monthly publication *Public Roads—A Journal of Highway Research* in 1918, which continues to be published today by the FHWA.[227] Provisions of the Federal-Aid Act of 1921 kept BPR in control of national highway and bridge design.[228] BPR’s activities put research at the forefront, which was viewed as fundamental to good highway and bridge design.

During the 1920s-1940s, BPR officials focused on cooperative research by associating its efforts with the National Research Council, HRB, and AASHO. Moreover, state highway department testing facilities and laboratories, which BPR was responsible for, and engineering colleges became research partners with the HRB.[229] BPR offered guidance on use of new materials, incorporating results of testing that was done throughout the country and internationally.

Bridge design standards developed by federal engineers and BPR officials, were frequently disseminated under AASHO’s name.[230] The collaborative effect of these nationally disseminated design standards helped to position BPR as a non-dictatorial, cooperative federal agency. BPR published its first edition of standard bridge plans in 1953 and periodically updated these plans to reflect new technologies and materials. The 1956 edition includes plans for a variety of highway superstructures of varying span lengths and roadway widths. Bridge types included in the BPR standard plan set reflected established bridge types and designs commonly constructed. Bridge plans were developed for I-beams, deck plate girders, concrete slabs, T-beams, box girders, timber spans, and prestressed concrete I-beams. Most, if not all, of these types appear to have been used in Indiana during the period. The plan sets were updated every few years to include new and improved designs. In 1962 BPR expanded its standard plans to a five-volume series, including concrete superstructures, structural steel superstructures, timber bridges, continuous bridges, and pedestrian bridges.

Guidance on prestressed concrete in the early 1950s was provided to ISHC and other state departments of transportation in BPR's *Criteria for Prestressed Concrete Bridges.* This volume highlighted best European practices prior to the material's widespread use in the United States. Prestressed concrete would become a significant bridge-building material. See Section 3D for further discussion of prestressed concrete.

(2) American Association of State Highway Officials

The AASHO, a professional organization of state highway officials and predecessor to the AASHTO, has a long history of defining and disseminating standard practices for road and bridge engineering. State highway officials from Maryland, Virginia, and North Carolina established this national professional organization in 1914 to facilitate discussion of issues related to road construction, including legislation, economics, and design. Discouraged with the rural road focus of OPR, AASHO leaders identified the federal road network and a federal roads bill as their first priority. During the inaugural AASHO convention in 1915, members ratified a revised federal roads bill which was then introduced to Congress by Senator J.H. Bankhead and passed as the Federal-Aid Highway Act of 1916.[231]

As early as 1921, AASHO had established a subcommittee on bridges and structures with the following mission:

> Cooperate with the different states and federal departments and other associations, societies, and institutions with a view to assisting in establishing uniform standard methods of construction and maintenance and in standardizing as much as possible the various kinds of construction used in connection with highway development.

In working towards its mission, AASHO published its first set of bridge specifications in 1931, although informal versions were available as early as 1926. AASHO's bridge specifications were intended to be a model for state highway departments, providing minimum requirements for bridge construction that could be tailored to meet local needs. AASHO specifications became one of the industry standards for guidance on bridge design and construction. Bridge specifications continued to be published periodically and influenced state bridge-building efforts.[232] Changes in standard specifications were reviewed annually by AASHO and revised periodically. Updated versions were published in 1949, 1953, 1957, 1961, and 1963. Regular updates reflected rapid changes and developments in new materials and technologies.

State highway specifications disseminated by AASHO committees, such as the committee on bridges and structures, often reflected BPR design philosophies and policies. During the 1920s-1940s, AASHO committees were generally headed by BPR officials, and bridge and road specifications released were frequently prepared by federal engineers. Together, BPR and AASHO established and implemented consensus design standards while seeking to standardize road and bridge-building practice itself.[233]

Examples of AASHO-BPR standard specifications include those for grade separation structures, released between 1938 and 1943 and revised thereafter.[234] In the 1944 revised publication of *A Policy on Grade Separations for Intersection Highways,* AASHO recommended the use of deck-type structures for grade separations, where the structure is underneath the roadway as much as possible with few supports, to provide drivers a limited sense of restriction.[235] Additional AASHO recommendations included that structures be visible to approaching traffic both day and night and that they be aesthetically pleasing.

AASHO also published roadway and bridge standards to address varying traffic needs, loads, and speeds. In 1945 AASHO's recommended design standards for highways, including structures to be constructed of steel, reinforced concrete or masonry, and preferably using deck construction, where supporting members of the bridge are all beneath the roadway. AASHO also recommended grade separations at intersections in rural areas where higher traffic counts warranted this safety measure.[236]

Several innovations were introduced in AASHO specifications after World War II. In 1949 a design method for plate girders was introduced that permitted thinner webs (the portion of a beam located between and connected to the flanges, or the horizontal part of a girder extending transversely across the top and bottom of the web) for long girders (the flexural members or beams that are the main or primary support for the structure).[237] In 1956 AASHO adopted *A Policy on Design Standards, Interstate System*, which included standards to address the new Interstate Highway System, including bridges to serve as overpasses and underpasses. Deck construction was recommended for bridges and overpasses to fit the overall alignment and profile of the highway. For all structures, the bridge clear height was recommended to be 16 feet to allow large vehicles to pass underneath. For all structures of 150 feet or less, including grade separations, bridge width was recommended to be the full approach roadway, including pavement and shoulders.[238] The 1957 specifications included new discussions on use of high-tensile bolts (bolts and nuts made of high-strength steel) and concrete box girders. Specifications were also added for structural steel welding that were "developed largely to meet the demand for weldable steel for highway bridges."[239]

Prestressed concrete was first included in AASHO standard specifications in 1961, largely based on the joint ASCE and ACI Committee on Prestressed Concrete report of 1958.[240] Other significant revisions in the 1961 edition based on the latest research and developments addressed the following topics: neoprene (elastomeric) bearing plates (a support element transferring loads from superstructure to substructure while permitting limited movement capability), plate girders, and high-strength bolts.[241] Updated recommendations were provided by AASHO in its 1965 publication *A Policy on Geometric Design of Rural Highways*. In this version, AASHO continued to advocate the use of deck-type structures and recommended prestressed deck designs for longer spans.[242]

Many policies, research results, and specifications developed and promoted by AASHO and BPR were incorporated into ISHC's post-war bridge program.

C. ISHC bridge building

(1) Early ISHC to the Great Depression

Under provisions of the 1917 state legislation that also created the ISHC, state and federal aid would be available for up to half the cost of bridges that followed ISHC specifications and plans, and were located on the newly designated state highway system. Plans and specifications for county bridges estimated to cost over $2,000 would be submitted to ISHC and contracts for construction could be awarded only on state-approved materials and design.[243] The state highway engineer was "the consulting engineer for the whole state in matters of highway or bridge improvements" and could be called upon by any county, city, or township officials for bridge advice and to furnish plans for bridge design and construction. The first requests for assistance on bridge work came from Marion, Fort Wayne, and Logansport.[244] Despite the lawsuit that stopped ISHC operations in 1918, the commission still managed to provide non-federal-aid bridge plans for projects in five counties.[245]

The Indiana legislature side-stepped the 1918 constitutional challenge and reconstituted the ISHC through a new law in 1919. Under the new legislation, the state had complete control of bridge design and construction on all highways in the state system, eliminating the partial control of the counties that existed in the 1917 commission law. ISHC involvement in county bridge design and construction remained the same as 1917. State highway bridges with a span over 20 feet would be let on a contract separate from any highway contract. Shorter-span bridges, generally considered to be culverts, would be included in a highway contract. Each bridge was to be bid under plans for "not less than two distinct types of bridges, one of which shall be of the type commonly known as steel bridge construction."[246] The first federal-aid bridge designed by the new 1919 ISHC, FA No. 1, was a skewed, 30-foot span of unidentified design in Elkhart County. The plans for FA No. 1, along with those for all the other bridges designed in 1919, were approved by BPR. In this year, ISHC also prepared standard plans for three types of culverts with spans under 20 feet.[247]

In 1920, early in the life of the reorganized ISHC, the Bureau of Bridges labored to complete "plans and specifications for all the structures on the National Road." This high priority may have been due to the fact that "the federal government insists that federal aid be restricted to continuous through routes." The requirement of the 1919 law that two plans be prepared for each bridge, one steel and one alternate, "practically doubles the preliminary expense on bridges," which, coupled with the shortage of "skilled men and limited office space," made it difficult to keep up with the work.[248] Concrete and steel bridge costs were compared for bridge contracts let in 1920-21 and costs per square foot were calculated. The costs, averaged for all contracts, were $6.75 per square foot of concrete bridges and $7.95 for steel. Costs for both types came down equally during the study period, favoring neither type. No analysis of the study was reported by ISHC and the implications are not known, but the issue of materials clearly was of concern in the years after 1919.[249] The comparative costs of the materials were noted briefly in 1922, but no conclusions were reported.[250]

Also in 1922 ISHC stated that its own maintenance department had constructed six bridges using ISHC plans. The bridges were small and either in isolated locations or were required too late in the season to award contracts.[251] Additional bridges reported as built by the ISHC maintenance department in 1924 included several steel truss bridges, concrete girder and slab spans, and a reinforced-concrete arch bridge.[252]

During the mid-1920s ISHC reported that William Titus, the commission's bridge engineer, was actively involved with AASHO sub-committee work in the preparation of national standards for steel and concrete bridges. Titus's work, ISHC said, "was in line with the efforts of the Bureau of Public Roads of the USDA and of the Department of Commerce for standardizing all such forms as much as is consistent with the best design and construction." However, Titus emphasized that the work involved standard specifications rather than standard plans, "because there is no standard-plan panacea which can be used as a substitute for careful structural design to fit the location of each particular bridge."[253]

Despite Titus' reasoning for site-specific bridge design, the ISHC annual report for 1924 noted that the bridge department had been preparing standard plans for steel truss bridges with spans of 225 and 250 feet and a roadway width of 20 feet, and spans of 60, 92, and 150 feet with a roadway width of 22 feet. Previously, ISHC had prepared standard plans for "steel spans of 200 feet or shorter" with 20-foot roadway width.[254] Additional plans were prepared in 1925, "gradually completing a set of standard plans for both structural steel and reinforced concrete superstructures."[255] ISHC prepared sets of standard designs for reinforced-concrete slabs in the 1920s of 12 to 20 feet, and for T-beam spans from 1922 to 1941, regularly extending the length until they reached 50 feet.[256] ISHC produced a continuous-slab design in 1929 but did not build a continuous-slab bridge until 1939.[257]

The 1924 report also made particular reference to reconstructing existing bridges instead of replacing them, noting that it "does not require particular skill" to specify removal and replacement of a bridge, "but it does required real engineering training and experience" to analyze and successfully reconstruct an old bridge. The report proceeded to identify a number of large steel bridges that had been reconstructed.[258] Despite the interest in repairs, new bridge construction surged ahead. ISHC stated that only three states completed more bridge projects in 1924 and speculated that Indiana led the nation in bridge projects in 1925.[259]

Table 1
County-Led Bridge Building

Prior to the establishment of ISHC in 1917-19, county and city governments dominated bridge building in Indiana. Of the more than 6,000 extant bridges constructed in Indiana through 1965, over 70 percent are currently under county jurisdiction. However, county and state jurisdictions represented in Indiana's 2006 county and state bridge inventory databases may not reflect the original building agency, as the state has acquired numerous county roads since the 1930s. Preliminary analysis of current databases suggests that before 1920 Indiana counties built at least 95 percent of extant bridges. Although the state began to build bridges in greater numbers after 1920, Indiana counties continued to play an influential role in bridge-building projects. The breakdown, by county and state jurisdiction, of extant bridges built in Indiana between 1920 and 1965 follows.

Post-1920 Indiana Bridges under County or State Jurisdiction

Year Built	Number of Bridges under County Jurisdiction	Percent County	Number of Bridges under State Jurisdiction	Percent State	Total Number of Bridges
1920-29	727	80	182	20	909
1930-39	861	68	411	32	1,272
1940-49	421	64	239	36	660
1950-59	667	61	429	39	1,096
1960-65	1,118	69	510	31	1,628

In addition, despite having less money to spend on highway construction than the state, Indiana counties accomplished a significant amount of road and bridge building between 1920 and 1965. For example, in the 1930s Indiana counties spent on average approximately 55-percent less money than the state for highway projects, including road and bridge construction, repair, and maintenance. Throughout the 1950s and 1960s, counties urged consulting engineers to design the most economical, cost-effective bridges possible. Bridge costs could be affected by local interests, such as proximity to steel manufacturers or concrete precasters.[260] The following table illustrates the amount of money disbursed by both county and state governments during sample years from 1930 to 1950. During this time, Indiana counties spent approximately half as much money on highways as did the state.

County and State Disbursements for Highways in Selected Years

Fiscal Year	County Disbursements (includes road and bridge building, repair, and maintenance)	State Disbursements (includes road and bridge building, repair, maintenance, and material testing)
1930	$ 13,168,338.22	$22,556,446.98
1935	$ 7,575,585.53	$19,472,781.61
1940	$10,010,211.49	$ 21,170,219.90
1945	$12,157,330.35	$19,481,845.60
1950	$19,597,989.74	$34,086,833.59
Mean	$12,501,891.07	$23,353,625.54

Sources: Indiana Department of Transportation, *County and State Bridge Inventory Database*; "State Highway Commission of Indiana," in Year Book of the State of Indiana for the Year 1950 (Indianapolis, Ind.: [1951]), 156; "County Disbursements," in *Statistical Report for the State of Indiana*, 1930-1951.

(2) Great Depression through World War II

Throughout the 1920s and 1930s the basic hierarchy of federal, state, and local governments, including their relative positions in the hierarchy of financial and design control over bridges, remained largely the same. What changed was not so much the policy but the distribution of actual roads and bridges. Counties increasingly divested themselves of highways and bridges, especially during the Depression when local dollars were required for relief efforts. The state's share of the highway system, primarily the heavily traveled roads, expanded as county shares declined. With the explosion of federal spending under the New Deal, the amount of money flowing to the states increased dramatically, affording more state control. The state directed some of these funds to bridge construction. The emphasis on unemployment relief that motivated many New Deal agencies often produced bridges that used traditional materials, such as stone and timber, because of an emphasis on hand labor in projects involving CCC camps and WPA programs.[261]

As automobiles, trucks, and buses increased in size and quantity, and as their power and speed grew, bridge engineers noted with increasing alarm the inadequacies of existing bridges. Mostly, the older bridges were too narrow and their alignments were inappropriate for the new vehicles they served. ISHC annual reports regularly complained about narrow bridges. The annual report for 1933 identified over 100 bridges with only a quarter or less of the load capacity of a "standard new bridge," and over 700 bridges and culverts with roadway widths of 16 feet or less.[262] The 1936 report noted "the large number of narrow, weak and seriously damaged bridges and those on dangerous alignment [that] are a continuing menace to traffic…."[263] Many of the inadequate bridges were on roads that the state took over from counties as transfers accelerated during the Depression and New Deal.[264] In 1939 an ISHC general inventory concluded that over 1,900 bridges (including spans 10 feet and over) were "below the present standards of width, strength and alignment"—an interesting statistic given that 1,855 bridge contracts had been awarded by ISHC since 1919. It is little wonder that the commission regularly complained that it could not keep up with the demand for adequate bridges.[265]

In the mid-1930s ISHC began to design bridges appropriate to new highways that responded to increased highway speeds by creating longer curves, eliminating sharp turns, and separating the travel lanes. "During the past year," ISHC said in 1935, "we have demonstrated that bridges can be built on alignment curves with super elevation, as well as vertical curves…"[266] A year later ISHC would report that work had begun on the state's first divided-lane highway.[267] More divided-lane highways would be added in subsequent years.

(3) Post-World War II

Bridge construction during World War II was limited to work on the National Strategic Network and defense access roads. Construction was complicated by a shortage of engineers, labor, and materials—especially steel. In bridge work, "many gravity type concrete arches are being constructed to eliminate the need for reinforcing steel." Wood culverts were built in place of other types.[268] Overall during wartime, ISHC did more maintenance than construction: "a small number of new structures were built where it was absolutely necessary in order to keep heavy traffic moving."[269]

A discussion of bridge "standards" appeared in the 1948 report, *Highways of Indiana*, which stated that retaining narrow bridges on modern highways was a false economy. The report highlighted the new expressway-type highways that were being developed on the model of the Tri-State Express Highway being constructed across northwestern Indiana between Detroit and Chicago. The Tri-State had design features soon to be more commonly identified with the Interstate Highway System: wide, divided, lanes with limited access and "heavy-duty" construction. The Tri-State, the report explained, "is representative of the policy" of Indiana to develop and maintain an up-to-date highway system. On the principle that "a road is no wider than its bridges," new highways like the Tri-State demanded wide bridges (wider than the pavement if over 80 feet in span), with wide approaches, and a load capacity for a 20-ton truck. For divided highways with a median of 50 feet or more, twin structures were required. Secondary roads, following a similar design approach, required 28-foot clear roadways with safety walks of 2 feet for a steel truss bridge or 1 foot for other designs. The type and material of a bridge was of less importance than its widths and clearances, and was simply to be the "most economical for the purpose, with proper regard for architectural appearance where esthetics are of prime importance." Railings were to be open or solid in rural areas and open in urban areas. No railing designs were indicated.[270]

In the years after the commencement of the interstate highway construction program in the mid-1950s, ISHC annual reports paid considerable attention to Indiana highways, but said little about the details of the state's bridges. The bridges were simply pieces of the larger highway system—in aesthetic terms, this was taken quite literally, as the bridge structure merged seamlessly, and purposefully so, into the long, endless flow of concrete pavement. New construction involved prestressed concrete beams, which, to a large degree, became the now-minimalist superstructure.[271] The Interstate work claimed increasingly large amounts of staff time and bridge projects were sent to consulting engineers outside ISHC.[272]

Beginning in 1956 ISHC was occupied with widening many older, narrower bridges using pre-cast slabs. It was considered to be a worthy project because of the small investment of money and time for each structure. About 300 bridges appear to have been widened this way each year from 1956 through at least 1959. It is not clear when the extensive widening program ended, but it affected hundreds of bridges.[273]

For all the significant advances in highway and bridge technology following World War II, including the introduction of new concrete and metalworking technologies, such as prestressed beams and welding, the ISHC annual reports are silent on their use in Indiana.

(4) Purdue University Joint Highway Research Project

In 1936 ISHC and Purdue University established the Joint Highway Research Project, now known as the Joint Transportation Research Program. The Indiana state legislature provided further authorization for the project in 1937. Funded by ISHC, the Joint Highway Research Project of the Purdue Engineering Experiment Station was created to develop "the best methods of improving and maintaining the highways of the state and respective counties thereof."[274] The objectives of the project were five-fold:

- Basic studies of materials used in highways.
- Economical design, construction, and maintenance of county and state highways.
- Traffic, safety, and other miscellaneous studies as desired and agreed upon by both staff and the advisory board of the project.
- Advanced instruction in the fundamentals of highway engineering and related research.
- Practical experience in construction and maintenance procedures and use of materials.[275]

Research published by project staff most frequently related to pavement material and performance, traffic, and cost. Known examples of material research are discussed in Section 3.D.

In addition to funding the Joint Highway Research Project, monies secured by the 1937 legislation provided for the Highway Extension program and the Annual Purdue Road School, both of which were independently organized as early as 1914. The Highway Extension program disseminated research results of Purdue University to county road organizations through local meetings, Highway Extension News and Highway Extension Bulletin. Highway Extension News was published monthly during the academic year and was free to state, county, and city road officials in Indiana. Both the News and Bulletin, which was published less frequently, were intended to enable monthly contact between road officials and Purdue University, thus stimulating collaboration. Additionally, the program provided inspection of county roads at no cost to the county. The inspection service was inaugurated in 1920, and by 1940 all counties had been visited at least once, and several had requested inspection services more than six times.[276]

The Annual Purdue Road School held its inaugural meeting in 1914, after the Office of County Highway Superintendent was established. County officials, engineers, and contractors attended the road school to keep abreast of developments in highway engineering. Legislation passed in 1937 secured money for the road school and also ensured the official cooperation of ISHC. Proceedings of the Purdue Road School were published and disseminated annually.[277]

In 1959 the Highway Extension and Research Project for Indiana Counties (HERPIC) was organized by Purdue University. The project responded to legislation authorizing extension and research programs for county highway departments. HERPIC, now known as Indiana LTAP, prepared manuals and bulletins of recommended engineering and maintenance procedures, organized regional workshop conferences, and provided training to county highway and road officials.[278]

From 1937 to 1966, ISHC and cooperating institutions and organizations conducted studies that directly and indirectly affected bridge-building efforts in Indiana. Purdue University organized several programs that conducted research and provided educational experience on a wide variety of transportation and engineering topics, including the materials, design, construction, and maintenance of roads and associated bridges. Research attention was also given to economic factors, with the goal of providing economically efficient structures. In collaboration with Purdue University, ISHC increased its research efforts and communicated highway engineering developments with state, county, and city roads officials. The next section addresses developments in specific materials and bridge types used by local, county, and state officials for bridge building.

D. Bridge materials and types

Prior to 1966 Indiana's road networks featured both established and new bridge designs. New types were introduced based on research and technical advancements throughout the period. Generally, nineteenth-century bridge construction conformed to established types such as timber and metal trusses and stone arches. While these three bridge types were frequently used in Indiana, comparatively few remain; combined, the timber covered bridge, metal truss, and stone arch account for less than 10 percent of extant bridges built prior to 1966 in Indiana. Through research and experimentation, new types were introduced and utilized throughout the period by local bridge builders, bridge fabricating companies, and ISHC bridge engineers. During the twentieth century, advancements in materials such as steel, reinforced concrete, and prestressed concrete, impacted the types of bridges designed and utilized by Indiana's engineers. Types such as steel beam or girder, reinforced concrete arch, and concrete slab, accommodated increasing span lengths and vehicular loads. These three models, in particular, were used extensively in Indiana during the twentieth century and represent the majority of bridges extant from this pre-1966 period.

This section discusses material and engineering advancements that influenced the evolution of bridge design in Indiana from the 1830s through 1965. Organized first by material, this section describes prevalent bridge types designed and constructed by bridge-fabricating companies, county forces, consulting engineers, and ISHC. The development of structural materials and bridge types are presented in chronological order, and each section on bridge-building material is followed by a discussion of design details relating to bridge type.

The bridge types described are those that are known to be extant in Indiana, based on a preliminary analysis of Indiana's county and state bridge inventory databases. There may be additional extant unidentified bridges that are not represented in the county and state databases. In-text dates and numerical data identifying remaining bridge types reflect preliminary analysis of bridge inventory information maintained by INDOT. Moreover, the bridge types are presented from a state-level perspective; county-specific information may be gathered in a subsequent phase of the project. Engineering and bridge-type terms are illustrated in-text and are defined in the glossary in Appendix A. Appendix B summarizes the use of various bridge types in Indiana, including percentage built, years type was in use, median span length and longest span.

(1) Timber

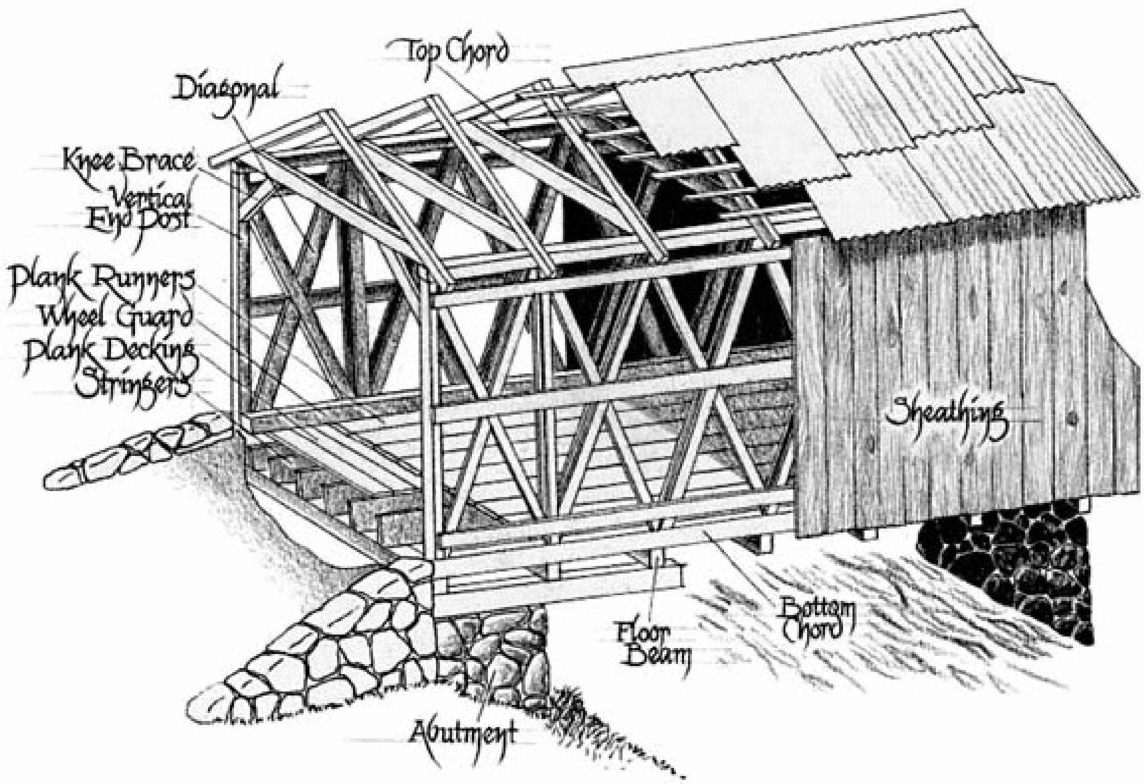
Timber was used for the earliest American bridges and continued to be used in certain locations due to its availability and low cost. An exposed wood bridge may be expected to last 10 to 20 years if not damaged by fire or flood. However, a covered timber bridge could last indefinitely, provided a substantial overhang of the bridge's roof protected interior timbers from decay. A covered timber bridge was considered an inexpensive alternative to stone bridges for long spans.[279] Wood was also used for pile-and-beam trestle spans with frequently placed piers, especially for railroad bridges.

Wood generally fell out of favor for highway bridge construction as transportation loads increased and new materials became economical. However, state and county bridge engineers continued to utilize creosote-treated timber, discussed below, for rural and county roads and untreated timber as a stop-gap measure for temporary bridge flooring during World War II when other materials were in short supply. Preliminary analysis of the state and county bridge databases indicates that bridges constructed of timber represent less than 2 percent of extant bridges constructed in Indiana through 1965. Moreover, 97 percent of these extant timber bridges are under county jurisdiction.[280]

Twentieth-century innovations in timber construction, which eliminated the need for bridge coverings, include creosote-treated timber and glue-laminated timber, known as Glulam. Creosote is a wood preservative that is obtained by the distillation of coal tar. A light treatment of creosote could approximately double the life of an untreated timber bridge by preventing decay and termite destruction. In 1935 civil engineers at Purdue University, in cooperation with the CCC and St. Louis Railway and American Creosoting Company, began conducting studies to assess the loading of built-up timber beams and compare creosote-treated timber with untreated timber.[281] In 1936 ISHC specified that preservative-treated Southern Yellow Pine, Douglas Fir, Red Oak, and White Oak were the preferred timber for permanent structures.[282] Glulam structures were experimented with nationally in the 1940s. Glulam is comprised of lumber layers that are bonded with a waterproof structural adhesive. Glulam was used nationally for girder and slab bridges; however, Indiana's use of Glulam is unknown.[283]

(a) Timber truss (covered bridge)

A truss bridge has a superstructure that features two parallel trusses, which use diagonal and vertical members to support deck loads. Diagonal and vertical members are joined with fasteners, such as pins or bolts, to create several rigid triangular shapes which are located between parallel bottom and top chords. A timber truss can be either covered or non-covered. The longevity of the span is increased if the timber truss is covered. In 1805 the first timber truss, a covered bridge, was erected in Philadelphia. Some of the first covered bridges in Indiana were constructed in Wayne and Henry counties, to provide access over waterways along the National Road.[284] By 1880 over 30 discrete timber truss designs had been introduced in the United States. Between 1835 and 1922, Indiana's bridge builders utilized approximately 10 of these designs to construct more than 600 covered bridges. Pine was the preferred timber for main structural members because of its strength and light weight. Because pine is not native to Indiana, most of the lumber was shipped from Michigan. Oak was usually used for bridge flooring and poplar was preferred for siding.[285] Timber trusses continued to be built in Indiana until the 1920s, although the type was not as popular in the twentieth century as steel and concrete bridge forms.



Covered bridge

Historically, approximately 63 percent of Indiana's timber trusses utilized the Burr arch design, and 30 percent used the Howe truss. Other less prevalent truss types, including the Multiple King Post, Queen Post, Smith, Long, Town Lattice, Wernwag, and McCallum Inflexible Arch, were also used. See Figure 6 at the end of the metal bridge type discussion for a diagram of these truss types. The Bell Ford Covered Bridge in Jackson County, which collapsed on January 2, 2006, was the last remaining Post Truss in the country.[286] Preliminary analysis of the state and county bridge databases indicates that 57 timber trusses located on Indiana's county highways and built prior to 1966 are extant.[287] Many of these extant timber trusses have been recognized as historic and are listed in the National Register.[288]

Burr arch

The Burr arch truss was patented by Theodore Burr in 1804. It uses a system of trusses in combination with a timber arch rib, which stabilizes and stiffens the truss. The continuous arch rib extends past the truss's bottom chord and rests upon the masonry abutment or pier. A Burr arch truss generally spans from 50 to 175 feet. The three major Indiana covered bridge builders—A.M. Kennedy and family, J.J. Daniels, and J.A. Britton, preferred and promoted the Burr arch design. Daniels often experimented with the design; for example, he tried placing an iron plate between the masonry abutment and lower end of the timber arch to prevent the wood from absorbing moisture at the abutment. Additionally, Daniels and Britton utilized metal tension rods that spanned the width of the bridge to secure the king post to the top and bottom chords of the truss.[289] Such incorporation of iron in wood structures predicted the eventual transition from timber to metal in bridge building. The Jackson Bridge, Parke County No. 199 (NBI: 6100148), a covered wood, double Burr arch truss over Sugar Creek has an unusually long span at 207 feet.[290]

Jackson Bridge, Parke County No. 199 (NBI 6100148).

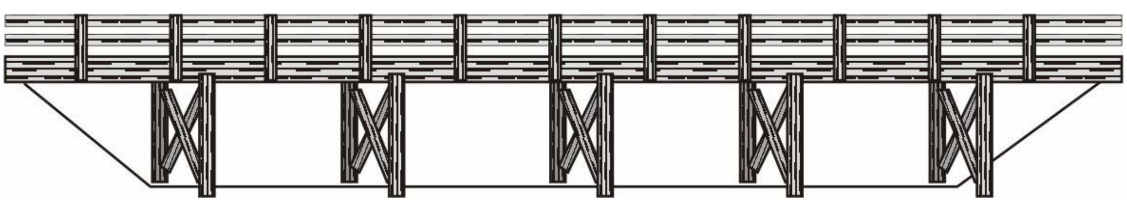
Howe

The Howe truss was patented by William Howe in 1840 and fabricated of both iron and wood. It features heavy timber diagonals that act in compression and lighter iron vertical members that act in tension. The iron members could be prestressed by tightening the nuts on the threaded vertical rods. This post-tensioning practice stabilized the truss and increased its strength and durability. Because of the integration of iron and wood materials, which resulted in increased structural strength, the Howe truss was a popular design for nineteenth-century railroad bridges. The Lancaster Bridge, Carroll County No. 18 (NBI: 0800014), is a covered Howe truss with unusual wrought iron abutments, patented by Alpheus Wheelock.[291]

Lancaster Bridge, Carroll County No. 18 (NBI: 0800014).

(b) Timber stringer

Simple wood beams, also known as stringers, could span about 20 feet. The timber stringer bridge type was commonly used in Indiana until the late nineteenth century when rolled steel beams generally began to replace timber stringers. Between 1934 and 1936, when there was a shortage of bridge-building materials, surveyors in Dubois County utilized 200,000 feet of creosote-treated native oak timber to construct approximately 60 timber stringer bridges and re-floor existing spans.[292] Additionally, ISHC contracted three multi-span, treated timber stringers in 1942, resurrecting "obsolete designs" to accommodate "the scarcity of material and labor" during World War II.[293] Fewer than 20 wood or timber stringers constructed prior to 1966 remain in the state.[294]



Timber stringer

(c) Timber slab

Preliminary analysis of the state and county bridge databases indicates that 12 timber slabs, constructed in Indiana through 1965, are extant.[295] The timber slab is comprised of timber panels, glued together end on end, and arranged in a longitudinal orientation, parallel to the flow of traffic. The boards often rest on transverse members or cross beams, which assist in distributing the load between timber panels. Timber slabs were popular in Indiana for use in state parks.

(d) Timber trestle

Preliminary analysis of the state and county bridge databases indicates that four timber trestles, constructed in Indiana through 1965, are extant.[296] First used in 1840, the timber trestle was a popular bridge type for railroads because the bridge type enabled a consistent grade for the track. A wood trestle is comprised of multiple braced timber frameworks that support short spans.[297] In Indiana, CCC engineers designed a "rough sawed timber trestle with a concrete road deck" for use in state parks.[298]

(e) Timber culvert

Since the 1830s, timber culverts were often erected on the canal system in Indiana, as they were the "most frequently used device[s] to get canals past intersecting streams."[299] Wooden rectangular or box culverts featured prominently, comprising over three-quarters of culverts that crossed lateral streams on the Wabash and Erie Canal in 1847. A timber box culvert has four sides, and a square or rectangular opening. To prevent deterioration, timber culverts were placed permanently underwater. Wooden arch culverts were extremely rare on canal routes.[300] Preliminary analysis of the state and county bridge databases does not indicate if any timber culverts, constructed in Indiana through 1965, are extant. Use of timber culverts for highway bridges in Indiana is unknown.

(f) Design details of timber bridges

Indiana's timber truss bridges often feature design details such as portal pilasters, brackets, and nameplates. For example, the Moscow Covered Bridge, Rush County No. 191 (NBI: 7000176), built by the A.M. Kennedy family, features decorative brackets under the roof eaves and applied scrollwork to the portal pilasters. Another feature of the timber truss is the shape of the portal opening, which often helps to identify the original builder in the absence of nameplates. For example, Daniels' bridges are distinguished by an arched portal, whereas Britton's portals feature a flat top with the outer edges sharply angled to meet the side panels.[301] Such decorative details, while representative of period bridge design, are often replacements added by contractors during rehabilitation of the structure. Railings are the primary design detail, albeit utilitarian, for the timber stringer, trestle, and slab.

Moscow Covered Bridge, Rush County No. 191 (NBI: 7000176).

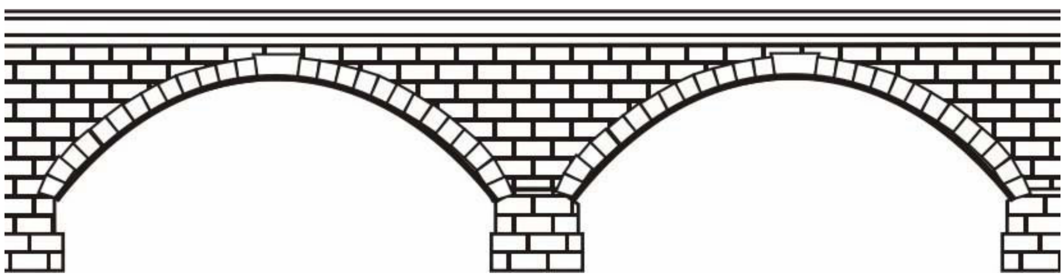
(2) Stone

Stone is a strong bridge-building material, particularly as used for arch construction. Except for the simplest stone slabs over narrow streams, all stone bridges are arches. Although the material requires little maintenance, stone was not readily used for highway bridges. The requirements for skilled labor and suitable, accessible material made the construction of stone bridges costly and time-consuming. Thus, its use in bridge projects was often limited to areas with a local supply of building stone or to usage by railroad companies who could afford to transport the material. Before poured concrete became common, stone was widely used in the construction of bridge piers and abutments.[302]

An 1891 report of Indiana's Department of Geology and Natural Resources identified 161 active quarries in the state, of which 25 explicitly reported extracting stone for bridge work. Laurel or Niagara limestone and carboniferous sandstone are two of the stone types identified as suitable for bridge work.[303] In 1894-95 Indiana ranked third in the nation in production value of limestone, following only Pennsylvania and Illinois.[304] Preliminary analysis of the state and county bridge databases indicates that bridges constructed of stone represent less than 1 percent of extant bridges constructed in Indiana through 1965. Of these extant stone bridges, 98 percent are under county jurisdiction.[305]

(a) Stone arch

The stone arch was an established bridge type in the United States by the 1700s. This form continued to be used into the twentieth century where suitable materials and skilled labor could be found. The stones that comprise the arch are called voussoirs; a keystone at the center locks the voussoirs into place. The solid spandrel walls usually support a filled roadway section. Relatively short spans were normal. A viaduct is a longer multiple-span structure that is comprised of shorter arch spans of similar lengths that are supported by heavy piers placed at frequent intervals. Although a stone railing may extend above the deck, a stone arch is always configured as a deck-type bridge. While capable of carrying heavy loads safely and requiring minimal maintenance, masonry arches were expensive and time-consuming to build.



Stone arch

Preliminary analysis of the state and county bridge databases indicates that 55 stone arches, constructed in Indiana through 1965, are extant. Of those identified in the databases, most were built between 1880 and the first decade of the twentieth century.[306] Included is a bridge designed in 1905 by Henry W. Klaussman to carry College Avenue over Fall Creek in Indianapolis, Marion County No. 1803F (NBI: 4900142).[307]

College Avenue Bridge, Marion County No. 1803F (NBI:4900142).

During the New Deal era there was a mild resurgence of stone arch construction. Numerous state and federal improvement projects utilized CCC labor for developing and beautifying state parks. CCC engineers had at least two stone arch park bridges under construction in 1935.[308] One extant example is the stone arch bridge over McCormick's Creek in McCormick's Creek State Park, Indiana No. P000-60-07083 (NBI: 60320). McCormick's Creek Bridge was constructed of local stone from a quarry near Ellettsville. The bridge has been recognized as historically significant and is listed in the National Register.[309]

McCormick's Creek Bridge, McCormick's Creek State Park, Indiana No. P000-60-07083 (NBI: 60320).

(b) Stone culvert

Most extant stone arch culverts in Indiana date to the nineteenth century and were built by local craftsmen. Stone arch culverts were often used for canal construction, when wooden box culverts were deemed inadequate and suitable stone was available locally. An 1847 survey of the Wabash and Erie Canal identified 14 stone arch structures, including one multiple-span configuration. Burnett's Creek Arch, Carroll County No. 181 (NBI: 0800119), is one early extant example of a masonry arch canal culvert.[310] Three pre-1966 remaining masonry arch culverts have been identified in Indiana, including Burnett's Creek Arch and two culverts that carry roadways over the Jordan River in Bloomington, Monroe County Nos. 902 and 917 (NBI: 5300104 and 5300134).[311]

Burnett's Creek Arch, Carroll County No. 181 (NBI: 0800119).

Jordan River Bridge, Bloomington, Monroe County No. 902 (NBI: 5300104).

(c) Design details of stone bridges

The aesthetic effect achieved by stone bridges is often the result of numerous variables, including quality, color, and finish of stone, coursing, and the delineation of the arch ring. Indiana's State Geologist identified the "pleasing color, or combinations of colors and a general effectiveness of appearance" as contributing factors in the "beauty" of stone.[312] With regards to bridge construction, stone finish is a critical design detail that is most apparent in the spandrel walls; polished or finished stone provides a distinctly different effect than unfinished or quarry-faced stone. The inclusion of a stone course also impacts the bridge's aesthetic effect. Spandrels may be uncoursed, irregularly arranged, or have a regular course, with stone patterned in rows. Additionally, the delineation of the arch ring, comprised of voussoirs and a keystone, impacts the bridge's appearance and emphasizes the structural form of the arch, which itself is often considered "one of the most beautiful engineering forms."[313]

Ornamentation of masonry arches is subtly achieved through the choice of stone, arrangement of material, and location of the bridge. As a result, there is often little applied ornamentation. W.D. Pence, a professor of bridge design, cautioned that the dignity of a masonry arch "may be lost even by a little faulty embellishment."[314] Moreover, CCC engineers adapted the stone arch to "fit" the landscape in which it was located, thus focusing on the broader aesthetic effect of a bridge in its setting.[315]

(3) Metal

Metal was first used in American bridges in the late eighteenth century; however, it did not become a popular structural material in bridge construction until the mid-1800s. The choice of metal used, whether iron or steel, changed over time, as did the method by which metal members were connected. Developments in the structural use of metal and connection methods are discussed in further detail below.

The classification system used to determine whether metal is cast iron, wrought iron, or steel (a derivative of iron) depends on the carbon level found in the metal. Cast iron has the highest percentage of carbon; wrought iron has been worked further to reduce the carbon level; and steel has the least amount of carbon. Carbon in metal reduces the ability to withstand tensile stress, which is a type of stress that tends to elongate the structural member and cause it to tear apart. Thus carbon makes the metal more brittle and likely to fail under tensile stress. Each form of metal possesses strength in compression.

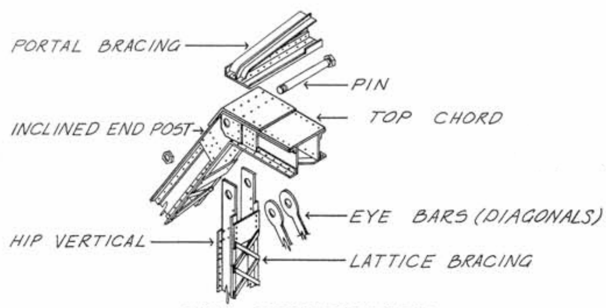
Cast iron was introduced into bridge construction in 1779 at Coalbrookdale, England, and first used in the United States for structural members in 1840. Used by both railroad and highway bridge builders, cast iron was originally combined with wood in bridge construction. Cast iron withstands compressive forces well enough, but performs poorly under tension. With its use of compressive forces, the arch bridge was most suited for cast iron construction. In America, the cast iron arch never gained popularity—probably because foundries were not able to cast the large pieces required to assemble an arch. By the 1850s cast iron lost favor and wrought iron became more popular.[316]

By the mid-1800s wrought iron, which had lower carbon content than cast iron and was a less brittle material, was readily used in bridge construction; however, the high temperature required to eliminate carbon made wrought iron production difficult and expensive. In the mid-nineteenth century an indirect method of producing wrought iron was introduced in America that used less fuel and allowed the material to be produced in larger quantities. Wrought iron is purer than cast iron and has superior tensile strength and ductility, which is the capacity to deform elastically, to stretch, bend or spread, to accommodate stress without fracturing. Because of these material characteristics, wrought iron could stand alone, supporting heavy live loads. Live load is weight a structure carries that is temporary in nature, such as traffic, wind, and seismic loads. The material was far from reliable, however, suffering from impurities that caused numerous bridge failures. Wrought iron was the preferred metal until the 1890s when steel, with its minimal carbon content, became a popular bridge-building material.[317]

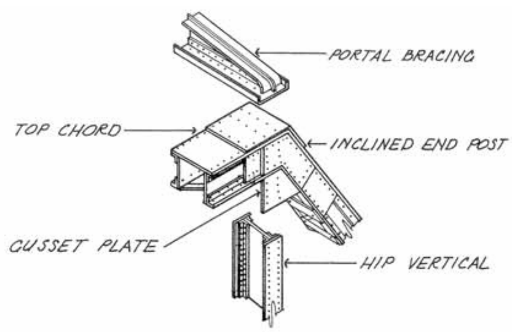
With the introduction of new manufacturing processes in the late nineteenth century, steel became available for structural use, including in bridges. Steel demonstrated strength and versatility, resisting the failure that had plagued its iron predecessors. Rolled steel beams were introduced in 1885, facilitating the material's use for short bridge spans. By 1895 steel overtook iron as the metal of choice. Improvements to steel in the late 1930s through 1960 increased the material's strength and durability. As a result, span lengths were able to increase and new designs were used. After World War II, the increased use of welding over riveting, to connect steel members, allowed the design of more economical and lighter steel superstructures. (See discussion of connection methods below.) Although bridge types such as the metal rigid frame, box girder, and channel beam were constructed in steel, none exist in Indiana, and therefore these bridge types are not discussed. Similarly, although there are no known extant suspension bridges constructed prior to 1966 in Indiana, we know of one notable self-anchored example built in 1939.[318] Additionally, several prefabricated steel Bailey trusses were erected after World War II as temporary emergency bridges; none are known to remain in Indiana.[319] Preliminary analysis of the state and county bridge databases indicates that metal bridges represent one-third of extant bridges constructed in Indiana through 1965. Of these extant metal bridges, 73 percent are under county jurisdiction, while only 27 percent are under state control.[320]

By 1925 aluminum was an established metal for construction. Its use was facilitated by production during World War I and a search for new applications following the war. As a bridge construction material, the advantages of aluminum include its economy, strength, ease of handling, corrosion resistance, and minimum maintenance. Aluminum was first used in bridge construction in 1933, when a new high-strength aluminum alloy floor system was designed and tested by the Aluminum Corporation of America in hopes of promoting the use of its product. In 1946 the Aluminum Corporation built an aluminum girder railroad bridge. Aluminum appears to have been primarily used in pedestrian bridges and utility crossings. It was rarely used for highway bridges, and no known examples exist in Indiana. ISHC used aluminum for culverts after 1945, and some examples remain.[321]

The connection of metal structural members has been achieved by a variety of methods, including pin connections, rivets, and bolts. The use of pin connections, introduced in the 1840s, allowed for easier erection of bridges, much of which could be completed offsite. Pin connections feature removable "pins" or pegs inserted into holes that are aligned in adjoining structural members. This connection type was most readily seen where the vertical member meets the top or bottom truss chords. Pin connections remained popular until the end of the nineteenth century when they were replaced by bolting and riveting. Bolting represents an intermediate method of connection that was used to erect truss bridges during the early twentieth century. Bolts replaced pins in smaller bridges and some through spans, but were quickly superseded by riveting.[322] Factory-riveted connections emerged in the 1880s and field-riveted joints were introduced in the early 1900s. Riveted construction uses a gun-like mechanism to drive molten steel rivets into pre-drilled holes. The main structural members are riveted together using plates. Arc-welding slowly replaced riveting as an economical method for fastening metal structural members.



PIN CONNECTION



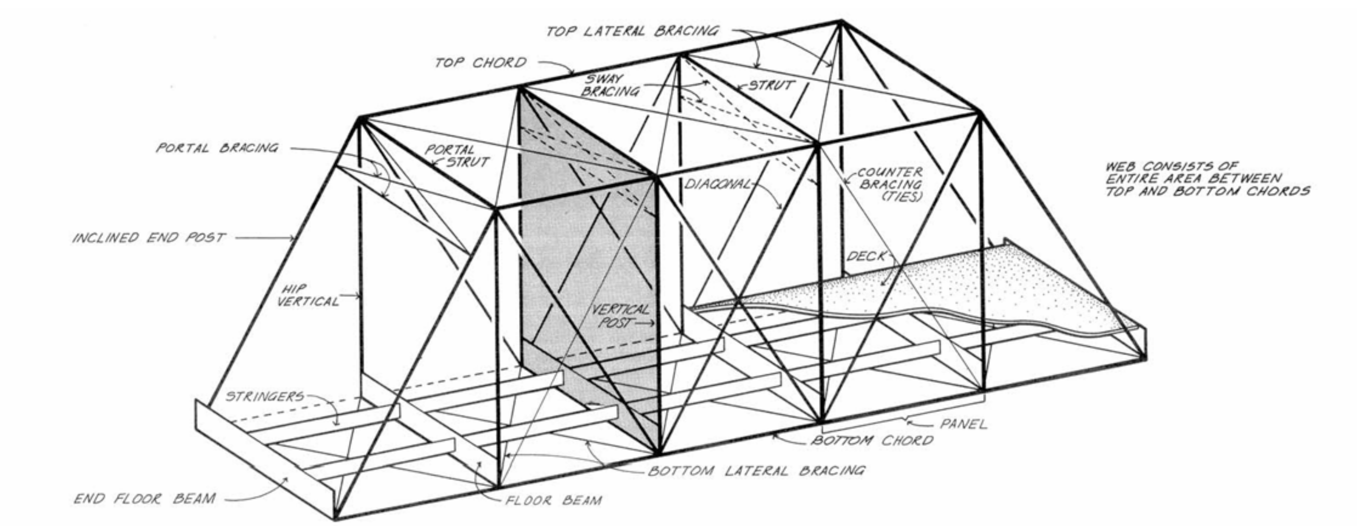
RIVETED CONNECTION

Arc-welding is a process by which steel parts are joined in their molten state, thus creating a metallurgical bond. Intense heat is provided to the joint by an electric arc. Before being applied to dynamically loaded structures, such as bridges, arc-welding was reserved for buildings and other statically loaded structures, including pipe work and shipping vessels during and after World War I.[323] Arc-welding was first applied to the connection of metal bridges in the 1920s, and the process was readily accepted by the 1940s. The first arc-welded structure in the United States was built in 1927-28 over Chicopee Falls in Massachusetts. This welded truss bridge completely eliminated rivets and used few bolts, and it employed one-third less the quantity of steel required by its riveted equivalent.[324] In the early 1930s all-welded highway bridges were constructed in France, Germany, and Poland, and by 1935 a small number of all-welded structures were constructed in Canada and the United States, with the states of Connecticut, California, and Kansas taking the lead. Beginning in 1939, ISHC did provide specifications for bridge construction welding. The ISHC specifications conform to those established nationally by the American Welding Society in 1936.[325] ISHC engineers chose to use welding if it was shown to be more cost effective than riveting. To check the soundness of welds, ISHC conducted X-ray inspections.[326]

Use of high-tensile bolts, manufactured from carbon steel and heat-treated for strength, was fairly new for structural steel connections in the 1950s. The Research Council on Riveted and Bolted Structural Joints approved and issued a *Specification for Assembly of Structural Joints Using High Tensile Bolts* in January 1951, allowing high-strength bolts to be substituted unit-for-unit for structural steel rivets of the same diameter.[327] At this time, high-tensile bolts were being used on railroad bridges and were seen as a favorable option because they were cheaper to use in the field than rivets. High-tensile bolts were used in Indiana in the 1950s for bridge repair work and the construction of interstate bridges.[328]

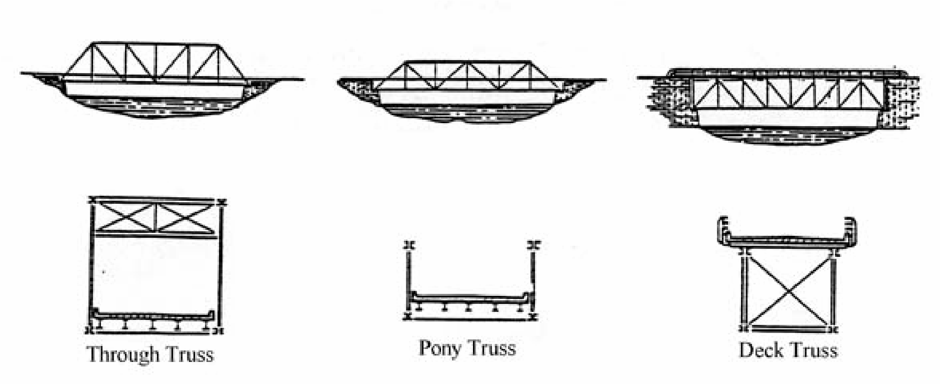
(a) Metal truss

Truss bridges became common in the United States in the mid-nineteenth century, and were used in Indiana by the 1870s. By 1924 ISHC had developed numerous standard truss designs for spans up to 250 feet.[329] A truss bridge has a superstructure that features two parallel trusses, which use diagonal and vertical members to support deck loads. Diagonal and vertical members are joined with plates and fasteners (pins, rivets or bolts) to create several rigid triangular shapes which are located between parallel bottom and top chords. This configuration can create long spans of relatively lightweight units.



Truss members

There are three basic arrangements of trusses—pony, through, and deck—and a wide variety of types. The arrangement is called a pony truss (or low truss) when it carries the deck near its top chord and there is not enough height to allow cross-bracing between the parallel top chords. The through truss (or overhead truss) features lateral bracing between parallel top chords located over the deck. The deck truss carries the roadway on its top chord.



Truss configurations

The choice of truss variant depended on the span length needed. The following discussion of various truss types identifies span ranges that were considered appropriate for each specific type. See Figure 6 at the end of the metal bridge type discussion for diagrams of various truss configurations. At the turn of the century, continuous and cantilevered designs were employed to achieve longer spans. Preliminary analysis of the state and county bridge databases indicates that more than 400 metal trusses, constructed in Indiana through 1965, are extant.[330]

Bowstring arch truss

In 1841 Squire Whipple received a patent for the bowstring arch truss. After Whipple's patent expired in 1869, the truss type was frequently erected by bridge-fabricating companies. This configuration features an arched or polygonal top chord, which is tied to a horizontal bottom chord; the top chord acts in compression and the bottom chord operates in tension. Diagonal members serve as bracing, and verticals support the deck. The bowstring generally reached spans ranging from 70 to 175 feet.

Critically linked to bridge-fabricating companies, such as the King Iron Bridge Company of Cleveland and the Wrought Iron Bridge Company of Canton, Ohio, the bowstring arch was heavily marketed to meet the demands of emerging farm-to-market road systems. This configuration was popular for "catalog" bridges, which were bridges sold to county commissioners through catalogs. Bowstring arches previously identified in Indiana include examples erected by numerous companies, including the two companies identified above.[331]

Pratt

Introduced in 1844 by Thomas and Caleb Pratt, the Pratt truss was originally designed to use timber and wrought iron. However, by 1852 the first all-iron Pratt was produced. The Pratt truss reversed the load-bearing system of the Howe truss, using its verticals in compression and diagonals in tension. The middle truss panel often incorporated a crossbar system to reduce buckling that could be caused by compressive loads. The Pratt truss was typically used to span lengths ranging from approximately 25 to 250 feet. As railroad companies began to favor all-iron bridge construction, the Pratt configuration was adopted as the standard for moderate span lengths.

Pratt trusses can be found in several variations. A full-slope Pratt has hip verticals in tension adjacent to inclined end posts. End posts of a Pratt half-hip are less inclined than those of a full-slope Pratt, and do not horizontally extend the length of a full panel. Introduced in the late nineteenth century, the Pratt half-hip truss generally ranged from 30 to 150 feet in span length.

Whipple

The Whipple truss was introduced by Squire Whipple in 1847 as a trapezoidal truss, and the first major variation on the Pratt truss system. This type was popular from 1860 to 1890 for spans of up to 250 to 300 feet. Whipple's patent featured a double-intersection web system and inclined end posts. An example is White County's Tioga Bridge which features two of the longest Whipple truss spans in Indiana at 225 feet each.[332] The status of this bridge is unknown.

The nation's only extant triple-intersection Whipple truss is located in Indiana and spans 302 feet across Laughery Creek, Dearborn County No. 95 (NBI: 1500079). The structure's diagonals extend across three panels to create a triple intersection, thus providing for short panels, a high truss, and a long span. Very few triple-intersection Whipple trusses were built.[333]

Laughery Creek Bridge, Dearborn County No. 95 (NBI: 1500079).

Baltimore

The Baltimore truss was patented in 1871 and named for the Baltimore and Ohio Railroad line, on which it was featured. Using a Pratt system of verticals in compression and diagonals in tension for inner bracing, Baltimore trusses often spanned 250 to 600 feet. The Baltimore truss features diagonals that are braced by sub-struts, thus providing an auxiliary framework connecting the diagonals to the parallel lower chord.

Pennsylvania

Like the Baltimore truss, the Pennsylvania uses a Pratt system of verticals in compression and diagonals, braced by sub-struts, in tension. Unlike the Baltimore truss, the Pennsylvania features a polygonal top chord. Patented in 1875 for the Pennsylvania Railroad, the truss often spanned 250 to 600 feet. By 1918 two nationally recognized bridges spanning the Ohio River to connect Indiana and Kentucky combined a number of Baltimore and Pennsylvania trusses to exceed 5,000 feet in total length. The 1918 bridge, designed for the Pennsylvania Railroad, featured the third longest single-span Pennsylvania truss in the world, measuring at 644 feet.[334] The status of this bridge is unknown.

Parker and Camelback

Developed in 1870 as an adaptation of the Pratt truss, a Parker span can be identified by its polygonal top chord of more than five slopes. Parker trusses spanned between 40 and 300 feet. In the 1920s, ISHC developed standard drawings for Parker spans, and the type became the state's preferred choice for a through truss. The Parker truss was utilized throughout the 1940s.[335]

A variation of the Parker truss is the Camelback. Introduced in the late 1800s, the camelback is a Parker truss with a polygonal top chord of exactly five slopes. Camelback trusses spanned between 100 and 300 feet.

Warren

The most common truss type used in the twentieth century was the Warren truss. This truss, patented in 1848 by two British engineers, eliminated verticals found in most other truss forms, using diagonals to withstand both tensile and compressive forces. Warren trusses can include verticals, but they serve more as bracing units than load-bearing systems. The span of this truss configuration generally ranged from 50 to 400 feet. Warren trusses were popular in the early twentieth century and were frequently used in Indiana once bolts and rivets supplanted pins as the preferred connection for structural members. In Indiana, the Warren truss was frequently used in a pony configuration; Warren through and deck trusses are rare.

Warren trusses can be found in several variations. Multiple-intersection Warren trusses, also known as lattices, feature double- or triple-intersection webs with inclined end posts and can span from 75 to 400 feet. Other variations include Warren trusses with polygonal top chords or vertical end posts.

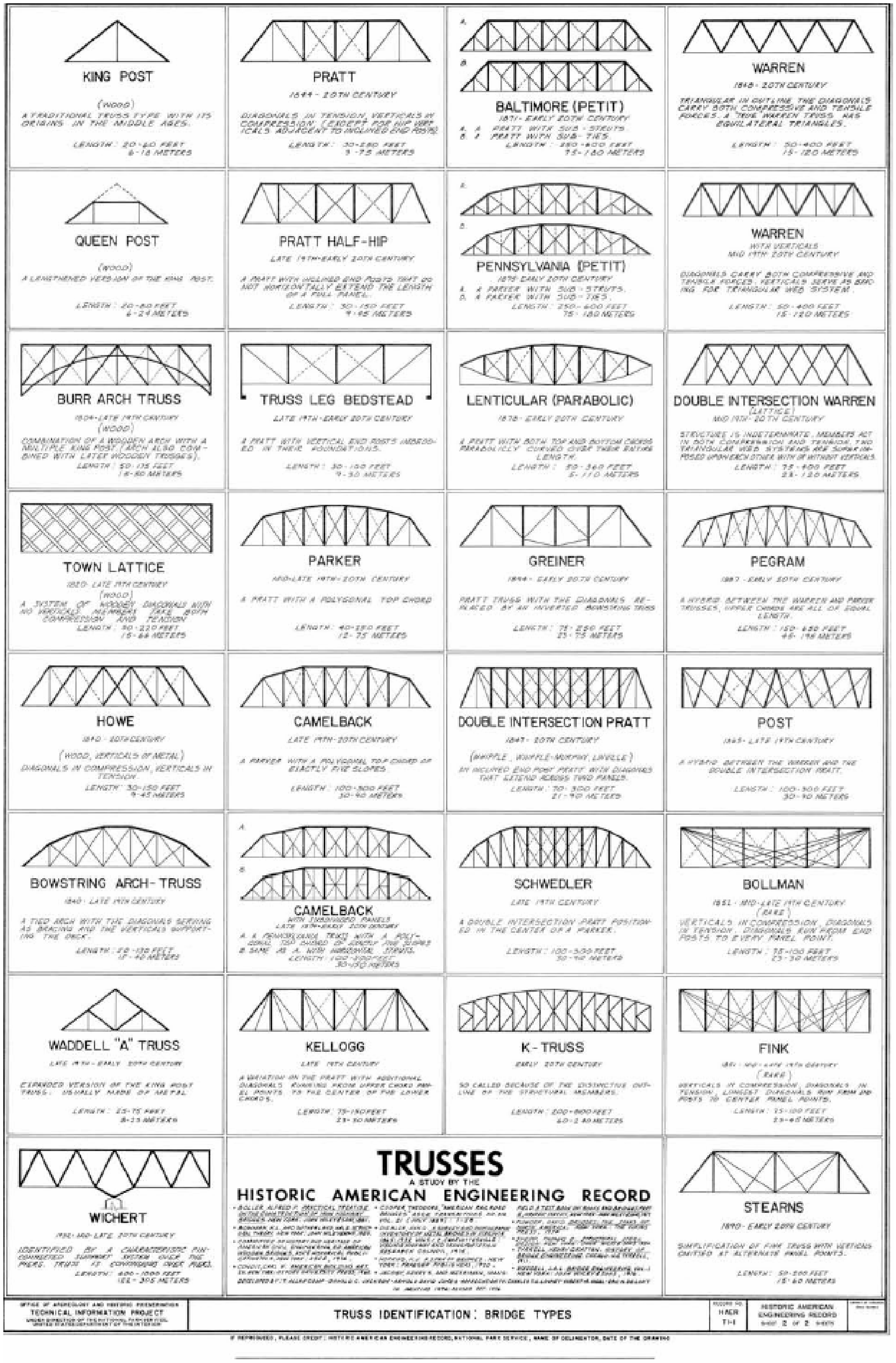
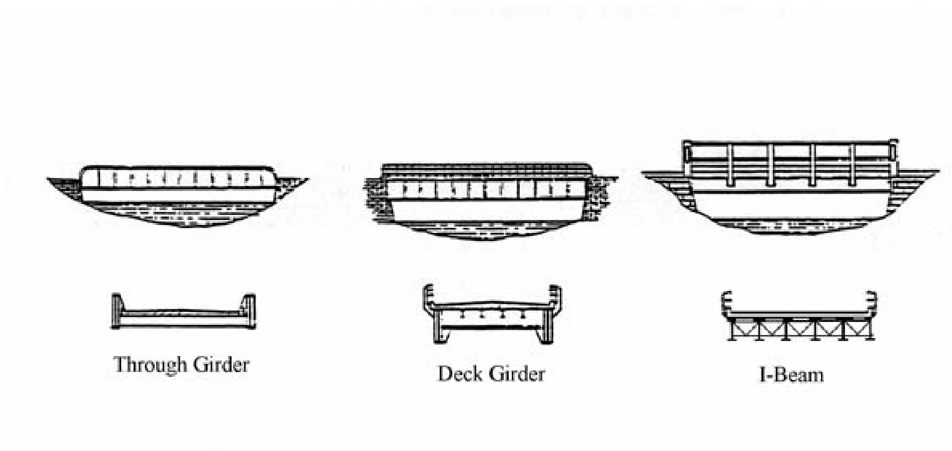


Figure 6. Truss bridge configurations

(b) Metal beam or girder

Beam or girder bridges use a rigid, usually horizontal, structural element supported by abutments and intermediary piers. The use of intermediate piers allows an almost unlimited total bridge length. Beam or girder bridges typically span between 100 and 320 feet, but can reach a length of 1,000 feet.

The metal girder bridge is composed of a series of steel structural members placed parallel to traffic, resting on abutments or piers. Steel girder bridges can be structurally classified as deck or through girders. Deck girders consist of a slab, or roadway surface, placed over two or more steel girders. A through girder is a structure in which the girder rises above the deck and appears as a parapet wall. Through girder bridges were prevalent in the early 1910s to 1930s. As roadways widened and concerns for vehicle collisions with parapets rose, deck girders became the norm after the 1930s. Steel beam and girder bridges are a prominent type in Indiana, and preliminary analysis of the state and county bridge databases indicates that more than 1,500 steel beam and girder bridges, constructed in Indiana through 1965, are extant. This constitutes a quarter of the total number of Indiana's extant pre-1966 bridges.[336]



Girder configurations

I-beam

The I-beam bridge takes its name from the structural elements of which it is composed. A steel I-beam is a joist or girder fabricated of rolled steel that has short flanges (or protruding edges) and a cross section that resembles the letter "I." The steel I-beam may or may not be encased in concrete. Rolled sections of steel were first manufactured in the United States in the 1880s. Early state-designed steel beam bridges in Indiana were based on standards developed by BPR.[337] In 1931 ISHC was designing rolled beam spans of less than 60 feet with a roadway width of 24 feet or more. This I-beam bridge type was considered more economical than steel trusses or plate girders of the same length.[338] The strength and size of I-beams increased in the 1930s, and continuous and cantilevered I-beam spans began to appear in Indiana during this period. By the late 1930s continuous steel I-beams could be produced at lengths of over

200 feet. By the early 1960s, rising steel prices and development of prestressed concrete beams ended the popularity of the steel I-beam.

Plate girder

A plate girder is fabricated of built-up riveted-bolted or welded steel plates with a deep web and top and bottom flanges. In a section, it resembles the letter "I." Fabricated plate girders have been used to span beyond the length of a standard steel I-beam. However, the longer the fabricated span, the deeper the girder was required to be. Standard plans were available nationally for plate girders by 1910 and the type enjoyed popularity as an economical construction method in many states where fabricated steel was readily available. In Indiana, plate girder spans were found to be economical for spans over 75 to 80 feet in length. Plate girders encased in concrete were considered economical for spans less than 75 feet because minimal exterior maintenance was necessary and less steel could be used because concrete provided the girder's web with lateral stability.[339]

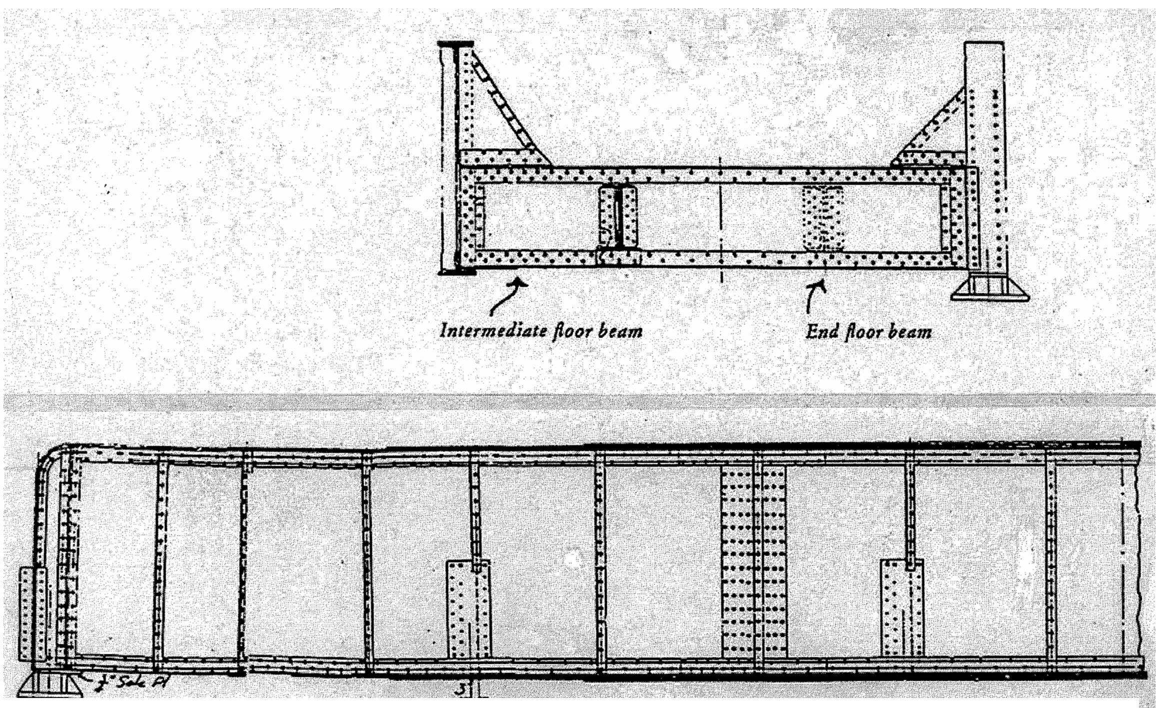


Plate girder

Although the Indiana Bridge Company began building plate girders in 1886, utilizing a patented "plate leg," most of Indiana's extant nineteenth-century plate girder highway bridges were fabricated by out-of-state firms.[340] Between 1910 and 1930, the Central States Bridge Company of Indianapolis became the predominant fabricator of plate girder highway bridges. An unusual and nationally publicized Indiana plate girder was the 1903 bridge over Wabash River near Terre Haute. This seven-span plate girder, which was replaced in 1992, featured Pratt deck trusses to support sidewalks on either side of the roadway. The plate girders were the "longest used to date for a highway bridge."[341] Variations included multiple and variable depth plate girders, in which a deeper girder was used at the pier or abutment.

(c) Metal arch

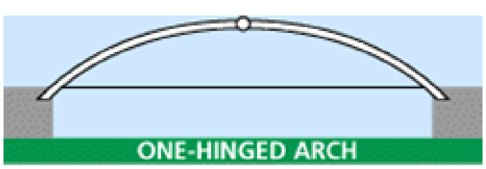
Introduced in the late nineteenth century, steel arches could create much longer spans than earlier masonry arches. Ribs of the steel arch are fabricated of beams, girders, or trusses and can be connected by rivets, bolts or welds. Three types of metal arches utilized in Indiana are discussed below; however, specific subtypes will be identified in subsequent phases of the project as needed. Preliminary analysis of the state and county bridge databases indicates that more than 20 metal arches, constructed in Indiana through 1965, are extant.[342]

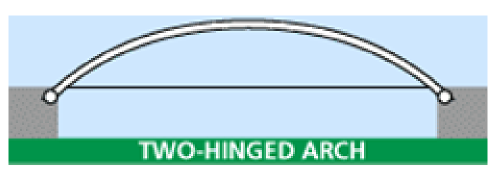
Tied arch

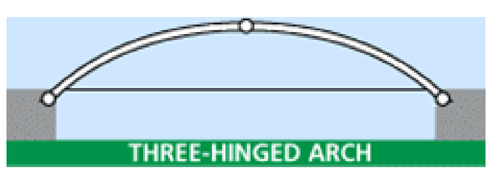
Steel tied arches, also referred to as tied through arches, are twentieth-century descendants of Squire Whipple's patented cast iron bowstring arch of 1841. The steel tied arch features an arch rib, or top chord, that operates in compression and a floor system that acts in tension. The floor system ties the ends of the arch ribs together and counters the horizontal thrust of the arch, such that smaller abutments could be used. Although steel tied arches were rarely built because they were difficult to fabricate and to erect, short spans of 30 to 50 feet and longer spans of 180 to 900 feet have been constructed. A nationally award-winning Indiana example of a steel arch is the Sherman Minton Bridge, which carries I-64 over the Ohio River, Indiana No. I64-103-04691C (NBI: 34520). Featuring double-decked roadways, this bridge was named the most beautiful new bridge by the American Institute of Steel Construction in 1961.[343]

Hinged arch

The steel arch often incorporates a hinged bearing system, using one to three hinges. By including hinges, the arch is able to adjust to expansion and contraction stresses. The single-hinged arch places the hinge at the apex of the arch to provide flexibility; however, this type was rarely built. The two-hinged arch pins the hinges at the base of the arch to limit rotational effects between the structure and the foundation. The two-hinge system also controls abutment movement and allows use of lighter construction materials. The three-hinged arch features hinges at the base and the apex of the arch, which compensate for the stress of expansion or contraction. The two-hinged arch is the most common of steel hinged arches, and spans can range from 500 to 1,675 feet.







Multi-plate arch

Introduced nationally by the Armco Culvert Manufacturer's Association in 1931, the fabricated multi-plate arch is a galvanized corrugated-iron sectional pipe. The prefabricated plates could be bolted together to quickly assemble an arch in the field. The multi-plate arch was usually attached to concrete or masonry abutments and often featured stone or concrete spandrel walls. When chosen for small WPA bridge projects, the incorporation of masonry spandrels, head walls, and abutments characterized New Deal convictions regarding "roadside beautification, local craftsmanship and labor-intensive public works projects."[344] In 1940 and 1941 United States Steel acutely marketed its version of the multi-plate arch in national publications as a bridge type that made "beauty without sacrifice of strength or low cost," and a product that enabled "fast work by the WPA."[345]

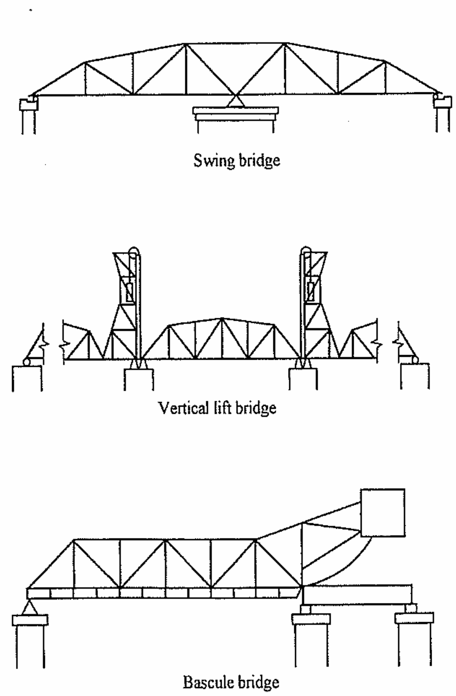
Prior to Armco's advancement of the "multi-plate," Indiana's county surveyors were using corrugated metal arches to repair failing metal and stone arch bridges, including a referenced Wabash County bridge in 1925.[346] In 1934 Ripley County surveyors used "multi-plate" to repair disintegrating reinforced concrete arches. Multi-plate construction was used to line the arch, strengthen the structure, and provide an inexpensive alternative to removing and replacing the old arch. Moreover, J.C. Eckert, Ripley County Surveyor, enumerated desirable features of multi-plate arches, including their strength, durability, speed of construction, and salvage value.[347] New metal multi-plate arch bridges were built throughout the 1930s featuring stone, concrete, and metal spandrels and head walls.

(d) Moveable spans

The three primary types of moveable spans are the swing, lift, and bascule. The swing bridge was introduced in the United States by the 1870s and employed a through truss that was anchored to a central pier and pivoted 90 degrees to allow vessels to pass through. When the swing bridge is open, each half is cantilevered over the water. As ship traffic increased, this bridge type fell out of favor due to the amount of space it occupied in the channel. The swing bridge was superseded by bascule, lift, and eventually fixed bridges with high vertical clearances. All extant swing bridges in Indiana were constructed by railroad companies, and therefore are not included in this study.[348]

Introduced in the 1890s, lift bridges typically use beams or trusses to span between two towers. The bridge deck is raised using cables attached to rotating drums in the towers. The deck maintains its horizontal position as cables raise the deck vertically, creating a channel for ships to pass through. There are no known extant lift bridges in Indiana.[349]

Bascule bridges were introduced in the 1890s and largely replaced swing and lift bridges. The bascule bridge utilizes a beam or truss deck that can be raised to an inclined or vertical position. To clear the waterway, the deck is either raised in a vertical plane or rolls back on a segmental rack.



(Source: Ann B. Miller and Kenneth M. Clark, A Survey of Movable Span Bridges in Virginia. Charlottesville, VA.: Virginia Transportation Research Council, July 1996).

Moveable bridges

Bascule bridges can be single-leaved, lifting the entire bridge to one side, or double-leaved, in which the bridge separates at the center. Types of bascule bridges include Scherzer-type rolling lift, simple trunnion, and Strauss trunnion.

The Scherzer-type rolling lift bascule, developed in the 1890s, has double leaves that rest on curved supports, or segmental girders, and roll backward to raise the leaves. The simple trunnion, introduced in the early 1900s, features plate-girder construction with a bottom- or rear-mounted segmental operating rack. The trunnion operates like a lever that pivots vertically. The weight of the bascule leaf is counterbalanced with a weight affixed to the end, near the operating rack. The Strauss trunnion, introduced in 1905, is a variation of the trunnion bascule that places all of the lever's counterweight at the extreme end of the leaf, using a pivoted and parallelogram framework. The simple trunnion became the most common form for a highway bascule. A number of bascule bridges were also built for Indiana railroads, and three examples, constructed through 1965, remain in use on Indiana's road system.[350]

(e) Metal culvert

Metal culverts take either a box or pipe form. The steel box culvert has a flat, or slightly arched, top and vertical sides. Its shape is well-suited for locations where there is minimal elevation differential between the road and stream. Box culverts are manufactured from standard structural steel that is reinforced with equally spaced ribs. They are available in spans up to 21 feet, though larger structures can be designed by combining multiple spans.[351]

Pipes have long been used as culverts with and without head walls (walls located at the end of a culvert to divert flow, protect fill, and to serve as a retaining wall). In the twentieth century, corrugated metal, steel, and concrete were typical materials. Pipes were prefabricated by manufacturers and shipped to construction sites. By 1940 Granite City Steel Company of Granite City, Illinois introduced "Nu-Arch Culverts," a half-circle section of corrugated metal pipe that provided economical and efficient culverts.[352]

(f) Design details of metal bridges

Indiana's metal trusses sometimes feature design details such as the elaboration of portal bracing and addition of finials, cresting, or nameplates. Latticed bracing and riveted embellishments may provide additional ornamentation. In addition, deck railings can provide inconspicuous decoration. The truss form itself, with contours that frame the landscape in a series of trapezoids and triangles, may be considered aesthetic.

The aesthetic effect provided by metal arches is somewhat different. For the multi-plate arch, attention to spandrel walls and the arch ring is significant. An unusual corrugated-iron arch was constructed in 1935 near Syracuse, Indiana, which featured spandrel walls and an arch ring constructed of multi-plate.[353] A 1938 WPA-built, four-span Armco multi-plate arch, featured concrete spandrel walls embellished with offset pilasters that continuously ran from the streambed to the top of the handrail.[354]

For metal beam and girder bridges, decoration is more limited and frequently confined to railings. In 1964 ISHC designed standard bridge railings which were endorsed by BPR for national use on steel and concrete interstate highway bridges. Although the railing was conceived with a focus on safety, strength, and cost, appearance was a specified criterion of design. By 1965 approximately 20 states had adopted the ISHC-designed railing for usage on steel and concrete state bridges.[355]

(4) Concrete

Concrete was first used in American bridges as early as the 1870s. Initially used without reinforcement, plain or mass concrete worked solely under compression and was only applicable to the arch form. Concrete became more common for bridge building after methods of reinforcement with metal wire and steel were introduced, improving concrete's tensile strength. By the 1930s prestressing was developed as a method of concrete reinforcement, becoming popular in the 1950s. Prestressing involves compressing concrete with heavily loaded wires or bars to improve its tensile strength. Developments in reinforcing and prestressing concrete are discussed in further detail below.

Lightweight concrete was a material innovation researched and utilized by numerous states to construct lighter structures. However, its use was somewhat limited by the fact that it was difficult to employ. Research has not identified any incorporation of lightweight concrete in ISHC structures. Nonetheless, in 1935 Purdue University researchers did conduct tests on small precast, prestressed Haydite concrete beams. Haydite is a lightweight ceramic aggregate. It is unclear whether the results of these tests influenced state bridge design.[356]

Reinforced and prestressed concrete are used in several types of highway bridges—from arches to beams and girders. Concrete allows a great deal of flexibility in bridge form. For example, arches can span longer distances and beams and girders can be built quickly and efficiently in many forms. Preliminary analysis of the state and county bridge databases indicates that concrete bridges represent the largest percentage of extant bridges constructed in Indiana through 1965. Of these extant concrete bridges, 70 percent are under county jurisdiction while only 30 percent are under state control.[357]

(a) Reinforced concrete

Varied methods of reinforced concrete were developed and used for bridge construction throughout the United States. The French engineer Jean Monier's patents for reinforced concrete were purchased by Gustav A. Wayss and introduced in the United States in 1884.[358] In 1885 the design competition for the Washington Bridge over the Harlem River in New York City included Thomas Clarke's unsuccessful proposal for a reinforced concrete bridge. Clarke's untested design recommended a two-span concrete arch in which the arch barrel would be reinforced with wrought-iron I-beams inserted at the crown and the haunches. Four years later in 1889, the first reinforced concrete arch in the United States was constructed in Golden Gate Park, San Francisco. In 1894 the first bridge in the United States using the Melan system was completed. The Melan system, developed by Josef Melan of Austria, utilized parallel steel I-beams that were curved to form an arch, embedded within concrete; it became a common concrete construction method.[359] Fritz von Emperger received two patents in 1897 for modifications to the Melan system—one added horizontal I-beams as reinforcing into the deck slab, and one inserted radial bars into the spandrel walls to join the arch and deck beams.[360]

In 1899 Edwin Thacher, an agent for von Emperger's firm the Melan Arch Construction Company, received a patent for a reinforced concrete arch that utilized a reinforcing system similar to von Emperger's. Thacher's system featured pairs of steel arch ribs, placed one above the other and frequently connected by stirrups, or radial bars. The reinforcing bars, which operated independently of each other and could be flexibly located in areas of high tensile stress, also extended into the abutment. Moreover, Thacher's reinforcing system was commonly used by BPR and state highway commissions such as ISHC during the 1920s and 1930s.[361]

The reinforced concrete arch in America, and specifically Indiana, evolved in the early twentieth century with Daniel B. Luten's extension of the Monier system of reinforcing. Whereas the reinforcing systems promoted by Melan and von Emperger were essentially concrete-encased metal arches, both Thacher and Luten began to develop reinforced concrete as a composite material, such that steel enabled concrete to withstand tensile stress.[362] Luten, a Purdue University professor and bridge designer, applied and patented a method of reinforcing concrete arches with longitudinal rods in tension that integrated the arch ring with the spandrel walls, abutments, and piers. The placement of the longitudinal rods inside the arch varied to address tensile stress. By stiffening the arch with tension rods, Luten was able to reduce the size of the substructure, thus saving material and space.[363] Luten's arch designs were prevalent both nationally and in Indiana and are described in further detail in the sidebar below.

Reinforced concrete has been used by ISHC since 1917 in a variety of bridge types. It was used both as the main bridge-building material and also in combination with steel and/or timber. ISHC-preferred reinforcing methods are currently unknown, but will be identified in subsequent phases of the project by reviewing bridge plans as needed. Further discussion of bridge types utilizing reinforced concrete is found below.

(b) Prestressed concrete

Prestressed concrete uses high-strength concrete containing high-strength steel that has been stretched and anchored to the concrete with sufficient force to significantly reduce tension from occurring in the member. Prestressed concrete is used for continuous and simple spans and is an effective way to increase concrete span lengths and control deflections. Deflections are the vertical movements that occur in a structure as a result of loading. Prestressing introduces a controlled strain in the member during construction to counteract unwanted stresses from the live or dead load, thus increasing the overall strength of concrete. Live load is weight a structure carries that is temporary in nature, such as traffic, wind, and seismic loads. Dead load is the permanent weight of the structure, including its deck, railings, and structural elements.

Prestressed concrete offers advantages over reinforced concrete. Prestressed concrete requires less concrete and steel than reinforced concrete spans. For example, a reinforced concrete girder uses much of its load-carrying capacity to support its own weight and this is increased as the structure lengthens. Prestressed concrete is different because a girder will support itself unencumbered by its own weight and allows longer structures to remain free of tension within the live-load range. Prestressing of concrete also prevents cracking, which is a common problem with reinforced concrete.

There are two types of prestressed concrete –pretensioned and post-tensioned. To form pretensioned concrete, steel reinforcing rods are stretched and placed into forms and held under stress until the concrete is poured. Once the concrete is hardened, it holds the steel to its stressed length. Post-tensioned concrete is formed when the steel rod or wire is inserted through open recesses or along the outside of the concrete member and is stretched and attached with a permanent anchor to maintain stress.

Experiments in prestressing concrete occurred as early as the late nineteenth century, but it was decades before it was practical to use. In the 1920s the idea of linear stressing became more practical through the work of French engineer, Eugene Freyssinet. In 1939 he patented the process that allowed the depth of large spans to be reduced by about half for the same concrete section.[364] Since prestressing offered economic advantages, during the Depression state engineers began to study and experiment with the material. Purdue University research engineers began testing prestressed concrete in the mid-1930s. Although early research was intended to assess beams for building construction, its future application to bridge design is significant. In 1934 research on prestressed concrete beams evaluated stress distribution and compared prestressed concrete with conventionally reinforced concrete.[365] State departments of transportation in Florida, Tennessee, California, and Pennsylvania were involved in early development and use of prestressing.

The first significant prestressed bridge in the United States was the Walnut Lane Bridge in Philadelphia, constructed in 1949. The use of prestressed concrete was limited until after World War II, when the economic use of materials was promoted because of the increased cost of building materials such as steel.[366] Prestressed concrete was used widely across the country by the early 1950s. In 1958 Purdue University researchers conducted tests to evaluate the effects of freezing and thawing prestressed concrete. This research used materials that met the specifications of the ISHC and focused on the material's durability by testing the hypothesis that frost is a catalyst for the deterioration of concrete.[367] In the 1950s and 1960s prestressed concrete was used for interstate structures throughout Indiana as it was often found to be more economical for long spans than steel.[368] In 1952 the Indianapolis News reported construction of the first prestressed concrete bridge in Indiana just off Indiana 54 northwest of Oolitic.[369] Research has not determined whether this bridge is extant. In its 1950s publication, *Criteria for Prestressed Concrete Bridges*, BPR published engineering specifications for prestressed concrete bridges. Prestressed concrete was not included in the AASHO specifications until 1961 due to continuing research and innovations throughout the 1950s.[370]

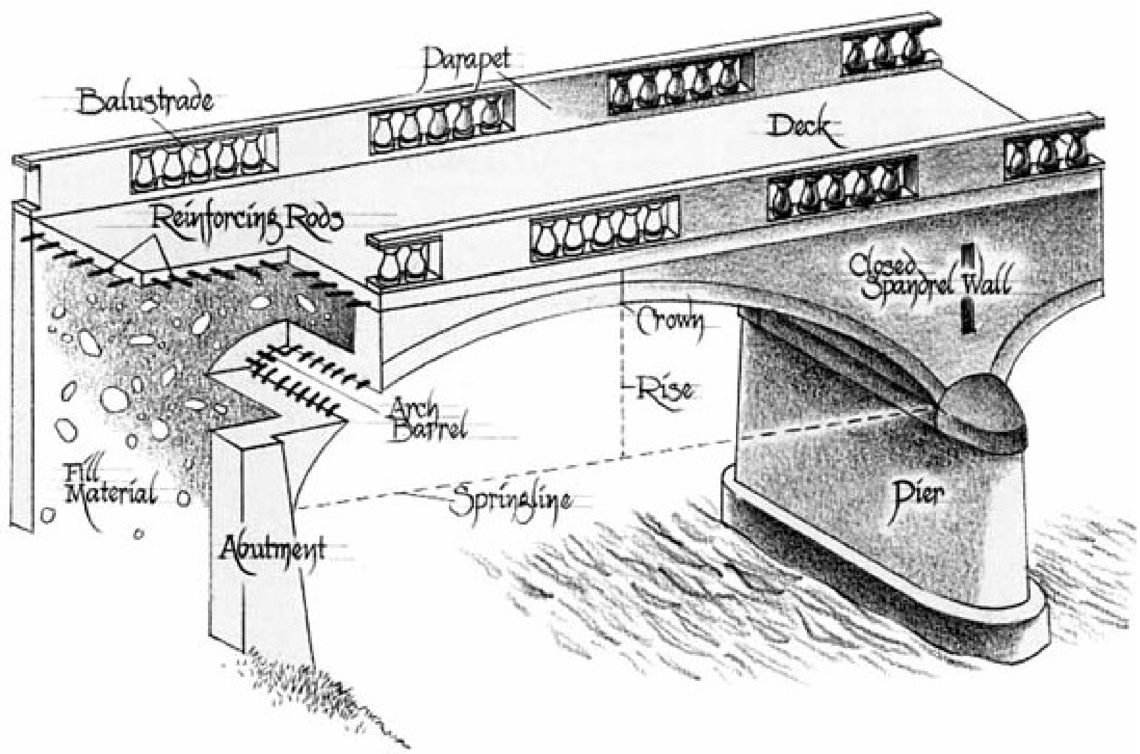
Precast, prestressed concrete was a material innovation that was popular after 1959, and innovations continued after 1965. Precasting of prestressed concrete units allowed cost savings as large quantities of beams and girders could be mass produced at factories and formwork reused.[371] Historian Carl Condit describes the importance of precast beams, "The precasting and prestressing of girders for concrete bridges have brought their construction as close to the methods of mass production as the building arts have yet come."[372] By the mid-1970s precast girders, more commonly of pretensioned concrete, were frequently being used for highway bridges nationally, with simple girder spans ranging from 50 to 100 feet.[373] Purdue research on precast, prestressed concrete included the development of the first precast, prestressed concrete bridge deck in America, which was installed in 1969 on Indiana Highway 37, now Monroe County No. 913, near Bloomington (NBI: 5300130).[374] Research has not determined whether this bridge is extant. Further discussion of bridge types utilizing prestressed concrete is found below.

(c) Concrete arch

Concrete arch bridges came into widespread use following the introduction of Josef Melan and Fritz von Emperger's reinforcing systems in the late 1890s. In addition, Daniel B. Luten played an important role in the development of reinforced concrete arch construction in both Indiana and the United States. His contributions are discussed in the sidebar below. Reinforcement enabled concrete arches to overcome limitations of the masonry arch. The arch ring is constructed either as a single-barrel vault or as a series of separate and parallel ribs. The concrete arch offered a graceful form and the opportunity for cast ornamentation. Preliminary analysis of the state and county bridge databases indicates that more than 650 concrete arches, constructed in Indiana through 1965, are extant.[375]

Closed spandrel arches are primarily used for short span lengths and often appear to replicate a masonry arch when the spandrel is faced with brick or stone. The spandrel is the area between the arch ring and deck. The spandrel wall retains fill material such as earth or rubble, which bear the live loads. Nationally, reinforced concrete closed spandrel arches date from the 1890s through the 1920s. Several Indiana examples of masonry-faced concrete arches were documented in 1915 by *Engineering News*.[376] Before World War II, the closed spandrel arch constituted one-fifth of the bridges designed and constructed by ISHC.[377] This type was extremely popular for urban and parkway settings. There are numerous concrete closed spandrel arches in Indianapolis, including the Meridian Street Bridge over Fall Creek, Marion County No. 1809F (NBI: 4900633), a monumental Beaux Arts design by George E. Kessler.

Meridan Street Bridge, Marion County No. 1809F (NBI: 4900633).



Closed spandrel bridge

First constructed in the United States in 1906, the open spandrel concrete arch became a popular form in the 1920s and 1930s, particularly for long spans and settings where significant vertical clearance was required.[378] As with steel arch bridges, concrete open spandrel arches were built in fixed, one-, two-, and three-hinge varieties. However, ISHC built fewer than a dozen during that time, probably because the open spandrel arch required more formwork than the closed spandrel version.[379] In 1926 William J. Titus, chief engineer of ISHC's Department of Construction, described a new, attractive, open spandrel concrete arch at Deer Creek, Putnam County No. 237 (NBI: 6700200).

The Arch Designs of Daniel B. Luten

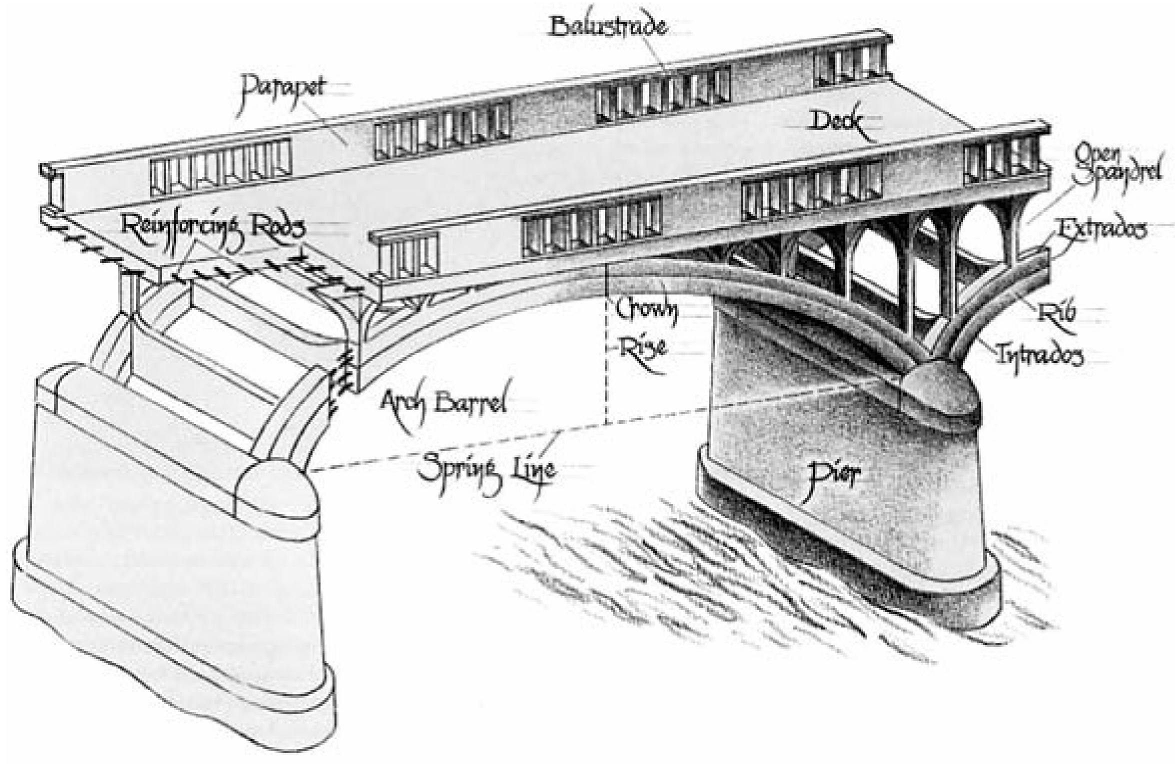
Daniel B. Luten, a Purdue University professor, bridge designer, and engineer based in Indianapolis, received national attention for his numerous influential reinforced concrete arches. James L. Cooper identifies Luten as a "designing and consulting engineer" who had considerable influence over North America. Cooper estimates that "approximately twelve thousand of his structures remain to bear witness to his once ubiquitous presence." The central tenet of Luten's design practice was to "produce a more efficient structure," by reducing the material required to build for a given strength. His innovative approaches to reinforcing concrete arches with longitudinal tension rods, discussed above, resulted in efficient bridge designs which he protected through the patent system. By 1915 Luten had acquired nearly 50 patents for his many reinforced concrete designs, including a design for arch-ring reinforcing, the steel-tied arch, and the ring-stiffened spandrel. Because Luten designed many arches, including open and closed spandrel, deck and through, barrel and rib, identification of his designs requires documentary evidence such as city and county records, bridge plaques, or comparisons to known Luten bridges. Approximately 46 reinforced concrete Luten arches, built between 1902 and 1930, were previously identified as extant in Indiana.[1]

Dr. James L. Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942* (N.p.: James L. Cooper, 1997), 37, 50, 52, 66; Parsons Brinckerhoff and Engineering and Industrial Heritage, "A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15," 3.58.

Deer Creek Bridge, Putnam County No. 237 (NBI: 6700200).

MEAD & HUNT

This four-span 347-foot-long bridge, which crossed a large ravine, featured a reinforced concrete deck that was integral with gable-topped floor beams. Moreover, Titus praised the aesthetic treatment of the span: railings echoed the spandrel contours, surfaces were carefully polished, and piers featured a bush-hammered finish that accentuated the bridge's structural frame.[380]



Open spandrel bridge

Reinforced concrete tied arches, also known as through arches because the deck passes through the arch at a midpoint, eliminate the need for massive abutments by having the arch tied to the abutment such that only vertical thrust is transferred to the substructure members. Only one tied arch was built in Indiana, E.A. Gast's bridge in Portland, which carries SR 27 over Salamonie River, Indiana No. 027-38-06182A (NBI: 7350). The design was based on an earlier bridge, designed by Gast, for Cincinnati. The Portland bridge was a significant contribution to the City Beautiful Movement in small-town Indiana and was nationally described as one of the first bridges of this type and design.[381]

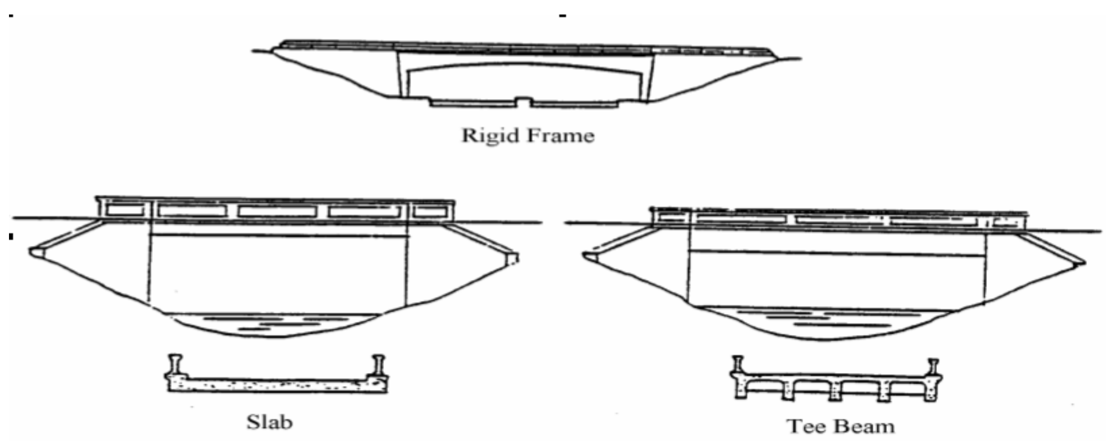
SR 27 Bridge over Salamonie River, Jay County No. 027-38-06182A (NBI: 7350).

In response to the scarcity of structural materials during World War II, ISHC began building numerous unreinforced or "gravity-type" arches. The arch eliminated steel reinforcement, thereby conserving critical materials. In 1942 ISHC awarded five contracts for this bridge type, which was planned using the three-hinge arch principle.[382] Two examples of unreinforced concrete arches remain from 1942: SR 64 over the Little Patoka River in Crawford County, Indiana, No. 64-13-3507 (NBI: 23050); and SR 75 over the Middle Fork of Wildcat Creek in Cass County, Indiana No. 75-08-3486 (NBI: 24960).

(d) Concrete slab

Preliminary analysis of the state and county bridge databases indicates that approximately 850 reinforced concrete slabs, constructed in Indiana through 1965, are extant.[383] A concrete slab structure includes a rigid horizontal monolithic slab that serves both as the deck and the structural member that carries stresses to the abutments and/or piers. By 1910 reinforced concrete slab structures were favored nationwide for shorter spans as the simplest and most economical of concrete bridge designs. After its formation in 1919, the ISHC quickly developed standard plans for concrete beams and slabs. The concrete slab was used extensively in Indiana in the 1920s; during the first half of the decade it accounted for one-fourth of all bridges constructed. However, by the 1930s, ISHC's usage of simple-span concrete slabs had dropped significantly.[384]

In 1929 ISHC developed a two-span continuous slab standard plan that reduced the depth of the span by approximately 20 percent compared with simple spans. The continuous slab introduced a single slab extending across several spans. However, it was not until 1939 that ISHC actually constructed a continuous slab structure.[385]



Beam and girder bridge type

The introduction of prestressed concrete in the 1950s allowed the concrete slab form to be used for spanning longer distances. However, ISHC's use of prestressed concrete slab is unknown.

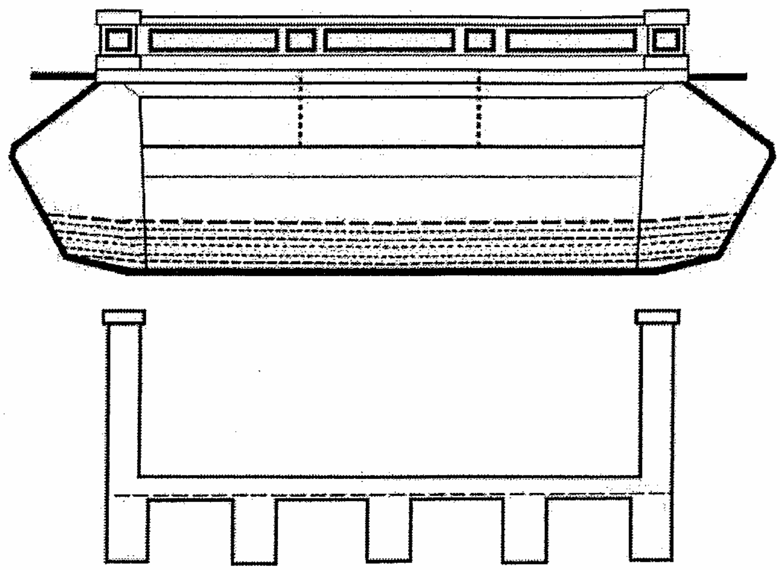
(e) Concrete rigid frame

Introduced in 1923 by New York bridge designer Arthur G. Hayden, concrete rigid frame structures feature the superstructure and abutments as a continuous form – poured monolithically in one mold. Rigid frames were commonly used across the nation for highway and freeway bridge construction. The bridge type generally spans up to 100 feet and has an arched profile. The first ISHC-designed rigid frame structure was used in a 1935 grade separation project in Delphi, Carroll County. The bridge carries North Street over US 421, Indiana No. (421)39-08-01788A (NBI: 32290).[386] Concrete rigid frame structures were popular on parkways and could be ornamented with stone facing. Preliminary analysis of the state and county bridge databases indicates that fewer than 20 concrete rigid frame bridges, constructed in Indiana through 1965, are extant.[387]

North Street over US 421, Carroll County No. (421) 39-08-01788A (NBI: 32290).

(f) Concrete beam or girder

Preliminary analysis of the state and county bridge databases indicates that more than 1,200 concrete girder bridges, constructed in Indiana through 1965, are extant.[388] The basic form of the concrete girder, which was constructed in both reinforced and prestressed concrete, was developed by the first decade of the twentieth century, resembling a steel-beam structure encased in concrete. Concrete girders employ large horizontal members spanning from abutment to abutment or abutment to pier, carrying the load in a post-and-lintel system. Concrete girder bridges rose to be the most common type of bridge in the United States. These structures can be constructed using various structural design concepts, including simple, continuous, and cantilever girder construction. Two structural system variations of concrete girder bridges include the deck girder and through girder types. The concrete deck girder bridge consists of a reinforced concrete slab with two or more girders below the bridge deck. In the through girder bridge design, the concrete girder is placed along side the bridge deck and projects above the deck, doubling as a parapet wall. The concrete girder with floor system bridge type is a structural configuration in which the girders are placed parallel to the roadway, connected by transverse floor beams that transfer the deck and traffic loads to the concrete girders.



Drawings of elevation and section of concrete girder. Adapted from Maryland State Roads Commission's 1919 "Standard Girder Bridges General Plan."

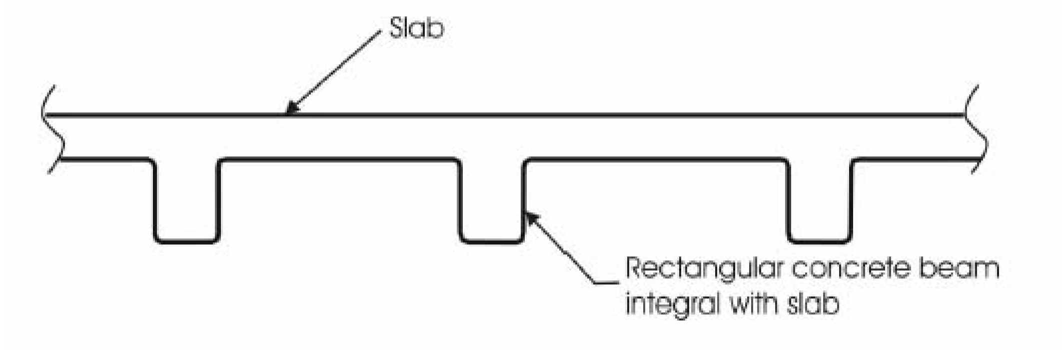
Concrete girder

Developments in prestressed concrete during this period include use of precast concrete beams and girders. In the early 1950s most states were constructing simply supported precast, prestressed beams, while continuous construction was only used by a few states.[389] Nationally, prestressed concrete girder bridges were largely economical and practical for medium spans from 40 to 100 feet, but were generally not cost competitive for spans below 30 feet.[390] With advances in technology, the use of precast, prestressed concrete became more common in Indiana and the nation.

ISHC first contracted a prestressed concrete girder bridge in 1958 and the number of prestressed concrete girder bridge construction projects that the commission let steadily increased after 1959.[391] Preliminary analysis of the state and county bridge databases indicates that more than approximately 380 prestressed concrete girder bridges, constructed in Indiana through 1965, are extant.[392] Variations of concrete girder bridges include the reinforced concrete girder, box girder, prestressed box beam, and channel beam, as discussed below.

Reinforced concrete girders

Concrete girders were built in Indiana in both reinforced and prestressed concrete, and feature a slab that is integrated with longitudinally oriented concrete girders. Standard plans for reinforced concrete girders were adopted by ISHC shortly after the commission's establishment and revised thereafter. During the 1920s and 1930s, reinforced concrete girders represented one-third of all bridges constructed in Indiana. The type's popularity can be attributed to its economical value over concrete arches and steel beams for spans longer than 25 feet. However, reinforced concrete girders were often less durable and more limited in span length than reinforced concrete arches, slabs, and steel beams. Between 1927 and 1938 ISHC standard T-beam spans were limited to 40 to 45 feet in length. Throughout the 1930s, ISHC's use of the reinforced concrete girder notably diminished.[393]



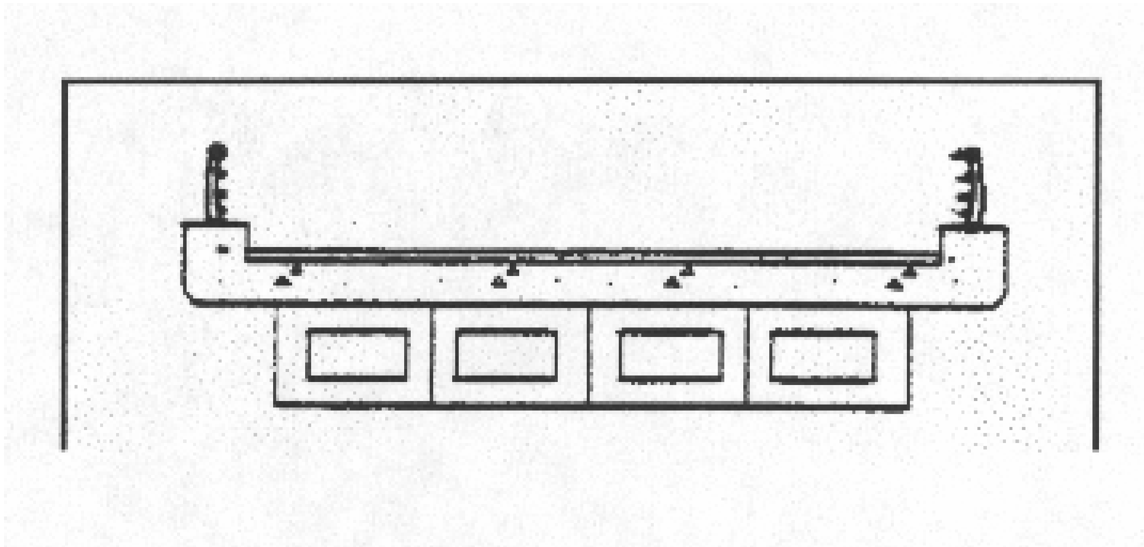
T-beam

Prestressed concrete girders were constructed following World War II and represent an advancement over the reinforced concrete girders of the 1910s. Precast, prestressed concrete girders provided economic and durable alternatives to steel and reinforced concrete designs. However, this type was rarely employed by ISHC; there is only one known extant example of prestressed concrete girders in Indiana, built in 1959.[394]

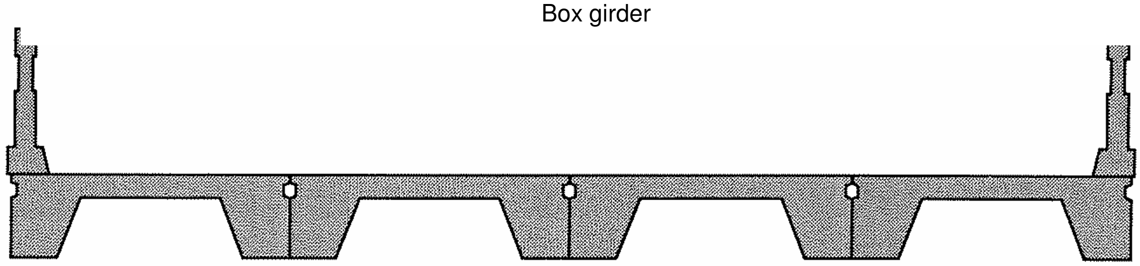
Box girder

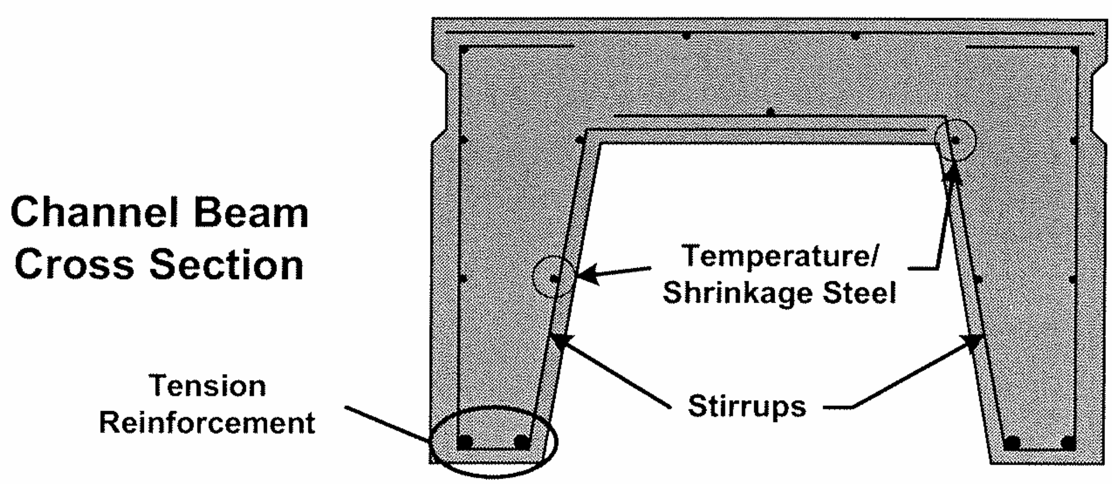
A variation of the concrete girder was the box girder, or box beam, which used a hollow box design. The first reinforced concrete box girders were built in the western United States in the late 1930s. Early ISHC box girders were designed such that the top of the beams constituted the driving surface. This configuration was later changed to a spread arrangement of box beams with a concrete slab deck poured on top to unite the beams.[395] Preliminary analysis of the state and county bridge databases indicates that fewer than five reinforced concrete box girders, constructed in Indiana through 1965, are extant.[396]

Prestressed concrete box beam bridges improved upon reinforced concrete box beam types of the late 1930s. These types were used nationally to a limited extent prior to 1960, and standard shapes or forms were developed by AASHO and Prestressed Concrete Institute (PCI) in 1962.[397] An early Indiana example of this type was built in 1959-1960 of prestressed precast concrete box beams. The type was chosen because it was economical, easy to erect, and provided good vertical clearance, as the box beams had little depth of construction.[398] Preliminary analysis of the state and county bridge databases indicates that approximately 380 prestressed concrete box beams, constructed in Indiana through 1965, are extant.[399]



Box girder





Channel beam

Channel beam

Another variation of the concrete girder bridge is the concrete channel beam bridge. The type has been utilized by state highway departments since the 1910s, and is frequently found in spans less than 50 feet. A channel beam structure features two rectangular concrete beams supporting an integral deck slab between them that is used for the roadway surface. This configuration results in an inverted U-shaped beam, which resembles a steel channel section and thus the name "channel beam." The channel beam was prefabricated in individual units and shipped to the bridge site where they were placed side-by-side to form a complete bridge. As in the reinforced concrete girder bridge, the integration of the beam or girder and deck increased the member's load-carrying capacity and provided greater stiffness. In addition, by prefabricating the channel beam, construction time was greatly reduced, the need to supply concrete to remote sites was eliminated, and the overall ease at which the bridge could be constructed was increased. Preliminary analysis of the state and county bridge databases indicates that approximately 200 concrete channel beam bridges, constructed in Indiana through 1965, are extant.[400]

(g) Concrete culvert

Concrete box culverts were built in the United States by the beginning of the twentieth century. ISHC developed standard designs for single and multiple concrete box culverts by 1919.[401] A concrete box culvert has four sides, some or all of which may be reinforced, and a square or rectangular opening. Span lengths for reinforced box culverts ranged between 10 and 50 feet; shorter spans were typically unreinforced.[402] Reinforced concrete single and multiple boxes were most commonly used, and standard plans were revised throughout the 1920s.[403]

Standard designs for unreinforced arch culverts were developed after 1941 to enable the completion of road projects in Indiana that were delayed by steel shortages.[404] However, the number of extant unreinforced concrete arch culverts, constructed prior to 1966 in Indiana, is unknown.

(h) Design details of concrete bridges

Indiana's early concrete bridges were predominately arches that mimicked the appearance of masonry arches. Reinforced concrete arches, particularly those associated with the City Beautiful Movement, featured spandrels clad in stone, pier pilasters and balustrades with neoclassical architectural treatment, refuge bays, and light standards. ISHC-designed arch spans reserved aesthetic treatment for bridge railings and pier pilasters, such that the critical structural members emphasized their concrete finish and form. The comments made by William J. Titus, ISHC Chief Engineer from 1919-33, regarding the Deer Creek open spandrel arch bridge, described above, exemplify the commission's standards for attractive bridge design.

For short-span bridges, especially concrete slab and girders, aesthetic treatment is typically limited to bridge railings. During Titus' tenure at ISHC, bridge railings often constituted the bridge's main decorative feature. Parapet rails displayed pier and abutment pilasters and featured a bush-hammered surface between the base and cap coping of the rail.[405] The standard bridge railings designed by ISHC in 1964 and described above in the section on design details of metal bridges were also used on concrete bridges. The first of these ISHC-designed railings, fabricated of aluminum, was erected in Indianapolis on a prestressed concrete box beam bridge carrying Massachusetts Avenue over Pogue's Run, Marion County No. 1909F (NBI: 4900156).[406]

E. Bridge design

Prior to the era of primarily state-governed bridge design and standardization of structural forms, which began in Indiana in 1920, bridges were constructed by local craftsman, bridge builders, and private companies. This initial era of bridge design in Indiana had a local flavor as designers and builders concentrated their work in certain parts of the state. With the establishment of the ISHC and broader use of standardized designs, bridge designs across Indiana became less dependent on local preferences and practitioners. Consideration for aesthetics also waned as production of bridge designs that could be erected quickly and inexpensively became increasingly important to the state's efforts to meet the burgeoning demand for transportation routes, especially after World War II.

Certain bridge types and materials lend themselves more readily to aesthetic treatment. In particular, arch bridges, in both stone and concrete, are frequently embellished with applied ornamentation and/or architectural treatment of the materials. For most bridge types, particularly beam and girder types, which constitutes 74 percent of extant bridges from the subject period, aesthetic principles were rarely applied and when they were incorporated typically appeared in railings. Design details and considerations applicable to specific bridge types are described further in Section 3.D.; likewise, examples of bridges displaying aesthetic design are identified in that section. This present section describes aesthetic trends in structural design in the United States and Indiana. It concludes with a summary of engineers, designers, and builders who are known to have executed bridge designs in the state prior to 1966.

(1) Aesthetics in bridge design

Whether or not a bridge design is aesthetic can be a subjective determination. The National Register recognizes aesthetic achievement in design and construction when a structure exhibits "high artistic values." Aesthetic ideals change over time and are influenced by the potential of the material used and the bridge type. In nineteenth and early twentieth-century bridge design, attention to aesthetics was largely a vernacular pursuit, guided by personal and community preference, and available skills and materials. Early bridges such as metal trusses fabricated by private bridge companies were frequently unadorned; decoration was applied only when clients requested and paid for such architectural treatment. Thus, aesthetic concerns remained in the hands of the client.

Stone arch bridges that survive in Indiana, built from 1880 to the 1940s, show aesthetic effects in the treatment of the material. Finishing and coursing of the stone and delineation of the arch ring were techniques used by builders to accomplish an aesthetically pleasing design. Many of these early stone arch bridge builders are unknown and, as such, unrecognized for their accomplishments.

Historian James L. Cooper has identified the 1893 World's Columbian Exposition as a decisive moment in the application of architectural aesthetic concerns to concrete bridge design. The elaboration of the Exposition's ideals by the City Beautiful Movement ensured the use of

Neoclassical design elements in structural design. Proponents of the movement argued for monumental structures that exhibited durability, strength, fitness, grace, and beauty. Thus, the arch form was frequently chosen for urban and parkway projects in conformity with City Beautiful dictums.[407] In Indiana, these ideals found expression in parkway bridge design of the early twentieth century, most notably in the parks and boulevard systems of Indianapolis and Fort Wayne. Section 2.D. provides more detail on the municipal improvements in Indiana spurred by the City Beautiful Movement.

However, as Historian Carl Condit notes, by 1910 there was generally a movement away from massive construction towards "the flattened parabolic curves of narrow ribs, the slender spandrel posts, and the minimal piers that scientific reinforcing was to make possible." [408] World War I coupled with the incorporation of bridge building into state and federal government and the development of standardized bridge plans brought changes to the aesthetics of bridge design. With disdain for the City Beautiful Movement, Daniel B. Luten, a Purdue University professor and nationally recognized bridge designer, advocated rational design, whereby a structure truthfully expresses its purpose with craftsmanship. Many Luten-designed reinforced concrete arches and other forms were built in Indiana; more than 40 examples remain.[409]

William J. Titus, ISHC Chief Bridge Engineer and later Chief Engineer (1919-1933), inherited a utilitarian approach to bridge aesthetics from Luten, with whom he had worked. In 1916 Titus authored an essay on artistic design in the third volume of George Hool's *Reinforced Concrete Construction*. Like Luten, Titus preferred honest, efficient bridges without "ginger-bread ornamentation." [410] In his essay, Titus defines artistic bridge design with regard to clarity of purpose, symmetry, harmony with the environment, proportion, and harmony of material and form. Moreover, Titus identifies the purpose of ornamentation to be the emphasis of structure, a clear proclamation of functional and pragmatic bridge design. In keeping with this aesthetic ideal, ISHC-designed concrete arch bridges emphasized the material and finish of the concrete and limited any decorative treatment to the railings and pier pilasters.

During the New Deal era, federal government programs, such as the WPA and CCC, were active participants in bridge design and construction. By exerting power through funding and employment, these programs frequently influenced the architectural treatment of bridges. Public works projects exhibited aesthetic treatment that reflected architectural styles such as Art Deco, Moderne, and Period Revival. The Art Deco style, which enjoyed its peak of popularity between 1920 and 1930, was characterized by the use of ornate geometric motifs to express contemporary trends of industrialization and modernization. Moderne style, or Streamlined Moderne, was a more restrained version of the Art Deco style and was popular from 1930 until World War II. Moderne designs featured smooth surfaces and curved corners. Designs based upon the continuation of the traditions of classical architecture are recognized by the general stylistic term Period Revival. The Rustic style was also employed for bridge design, typically on stone or stone-faced concrete arches built by CCC laborers. This style is generally expressed in the overall bridge form and contrast of natural materials.

Following World War II new artistic styles were embraced as a way to convey the spirit of the era. Modernism increasingly influenced architectural design throughout the United States. At the foundation of modernist principles, in all design arts, was rejection of traditional styles and ornamentation. Standardization and prefabricated parts played an increasingly important role in advancing construction methods. Availability of high quality craftsmanship had been largely absorbed and dispersed by the war effort.[411] Rational and technologically sophisticated designs proliferated for bridges, buildings, and structures of all kinds.

Modernism was profoundly influenced by new technology as innovative steel and concrete structural systems made possible unprecedented span lengths during the subject period. Bridge engineers often selected reinforced and prestressed concrete for their economy, but these materials also had aesthetic potential. In her 1949 book, *The Architecture of Bridges* published by the Museum of Modern Art, Elizabeth Mock noted that design excellence required an engineer's respect for economy of materials and proportion, combined with refinement of structural elements. She saw promise for the future of bridge aesthetics in the relatively new idea of structural continuity, which allows structural elements to be "literally fused into a single working shape," and in welded steel, as a material that can be molded into thin shells.[412]

By the end of the subject period, aesthetic considerations were even less likely to be part of bridge designs. Author Kenneth Frampton has noted that, by the mid-1960s, the "reductive codes" of contemporary design had "led to an impoverishment of the urban environment" in American cities.[413] A 1964 article in Traffic Engineering found fault with the design of grade separation structures of the era, calling for them to "pay more attention to architectural excellence." [414] This article's author, Joseph Barnett of BPR, was encouraged by a recent trend toward minimizing piers and columns through use of greater floor depth, which he thought resulted in an improved appearance. Barnett called for bridge engineers to be attentive to proportion and shadow lines.[415] In Indiana, ISHC annual reports and standards were generally silent on aesthetics.

(2) Engineers, designers, and builders

This section of the contextual study identifies engineers, designers, fabricators, and builders who are known to have been involved in bridge projects within Indiana through 1965. The list was compiled from references to designers and builders found in the bridge database maintained by Indiana's Department of Historic Preservation and Archaeology (DHPA); James L. Cooper's published studies, *Iron Monuments to a Distant Posterity: Indiana's Metal Bridges, 1870-1930* and *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*; and George Gould's seminal source on Indiana's covered bridges, *Indiana's Covered Bridges Thru the Years*. Table 2 includes the name of the bridge engineer, designer, or builder; geographic area of work; active dates of work; bridge type or form; and important notes.

Although it was a state agency rather than a designer or builder per se, the ISHC was responsible either directly or indirectly for the design of many of Indiana's bridges beginning in 1920 and continuing through 1965. ISHC designed state-owned bridges throughout this period. Through its dissemination of standard plans and specifications, the agency also influenced local bridge design by requiring local governments to meet state criteria in order to obtain federal funding. The bridge designs of ISHC are discussed in detail in Section 3.C.

Bridges can be listed on the National Register if they have an important association with a significant engineer, designer or builder. Such bridges are considered under National Register criteria to represent the "work of a master." This list of practitioners in Indiana is intended to assist with the identification of the important works of masters of Indiana bridge design during a future project phase. It recognizes known firms and individuals who influenced bridge building in Indiana. The list is a selective representation of notable Indiana bridge designers based on available information. Research into individual bridges that will be conducted in subsequent phases of the inventory project may identify other significant firms and individuals active during the subject period.

Table 2
Engineers, Designers, and Builders

Name of Bridge Engineer, Designer, or Construction Company, and Location	Geographic Area of Work	Active Dates of Bridge Engineering, Design, or Construction	Bridge Type or Form	Notes
American Bridge Company, Coraopolis, Pennsylvania	Nationwide	1872-1933	Metal truss	Purchased Lafayette Bridge Company in 1900; built steel manufacturing plant in Gary, Indiana (1909).
Attica Bridge Company, Attica, Indiana	North-central Indiana	1896-1901	Metal truss	Experimented with variations of large and small trusses and decorations.
Barker, B.F., Boone County Surveyor, Boone County, Indiana	Boone County, Indiana	Early twentieth century	Masonry arch	Built stone arch over Sugar Creek, Boone County No. 41 (NBI: 0600028).
Bellefontaine Bridge and Iron Company, Bellefontaine, Ohio	Midwest United States	1890-1894	Metal trusses	
Brackett Bridge Company, Cincinnati, Ohio	Midwest United States	c.1890-1901	Metal bridges	
Britton, J.A. & Sons, Parke County, Indiana	Southern Indiana	1882-1920	Timber-covered bridges	
Burk Construction Company	East central Indiana	1905-1930s	Metal bridges Concrete bridges	Pan-American Bridge Company manufactured most of the superstructures for Burk Construction Company.
Central States Bridge Company, Indianapolis	Nationwide	Early twentieth century	Metal truss	Successor to New Castle Bridge Company.

Table 2
Engineers, Designers, and Builders

Name of Bridge Engineer, Designer, or Construction Company, and Location	Geographic Area of Work	Active Dates of Bridge Engineering, Design, or Construction	Bridge Type or Form	Notes
CCC, Indiana	Statewide	1933-1942	Timber, masonry, and concrete bridges	Built numerous bridges in Indiana's state parks, including timber trestles and masonry arches.
Cole, C.W., City Engineer, Mishawaka, Indiana	St. Joseph County, Indiana	Early twentieth century	Concrete bridges	Designed several City Beautiful concrete arches.
Daniels, J.J., Parke County, Indiana	Southern Indiana	1850-1904	Timber-covered bridges	
Durfee, Josiah, Noblesville, Indiana	Central Indiana	1868-1881	Timber-covered bridges	
Elkhart Bridge and Iron Company	Midwest United States	Late nineteenth and early twentieth centuries	Metal truss	Won the first contract of both ISHC and the Michigan Highway Commission.
Gast, E.A., City Engineer, Cincinnati, Ohio	Portland, Indiana, Cincinnati, Ohio	1919-1937	Concrete arch bridge	Designed concrete tied-arch bridge for Cincinnati and used similar design for Portland's Meridian Street Bridge, Indiana No. 027-38-06182A (NBI: 7350).
Grosvenor, A.W., engineer, Fort Wayne, Indiana	Allen County, Indiana	Early twentieth century	Concrete bridges	Grosvenor's arch bridges were marked by the creative application of City Beautiful aesthetic principles. An example is the 1912 Tennessee Avenue bridge over St. Joseph River, Allen County No. 539 (NBI: 0200269).
Hammond, A.J., City Engineer, South Bend, Indiana	St. Joseph County, Indiana	Early twentieth century	Concrete bridges	Designed several City Beautiful concrete arches.
Hardman, Thomas A., Ripley County, Indiana	Southern Indiana	1870-1885	Timber-covered bridges	
Hardy, Frank Y., ISHC Bridge Engineer, Chief Bridge Engineer, Indianapolis, Indiana	Statewide	1920s-1969	Metal and concrete bridges	

MEAD & HUNT

Table 2 Engineers, Designers, and Builders				
Name of Bridge Engineer, Designer, or Construction Company, and Location	**Geographic Area of Work**	**Active Dates of Bridge Engineering, Design, or Construction**	**Bridge Type or Form**	**Notes**
Howe, Malverd, engineer, Terre Haute, Indiana	Statewide	Early twentieth century	Metal and concrete bridges	Professor at Rose Polytechnic Institute; wrote an *Engineering News-Record* article about his plate girder design near Terre Haute; consultant for at least two concrete arches (not extant).
Indiana Bridge Company, Muncie, Indiana	Nationwide	1887-1901	Metal truss	Most prolific Indiana bridge company.
ISHC, Indianapolis, Indiana	Statewide	1917-1965	Timber, masonry, metal, and concrete bridges	See Section 3.A. regarding ISHC's bridge designs.
Indianapolis Bridge Company, Indianapolis, Indiana	Statewide	1883-1885	Metal truss	
Jaap, G., contractor, Fort Wayne, Indiana	Allen County, Indiana	Early twentieth century	Concrete bridges	Was the foreman on Grosvenor's Tennessee Avenue Bridge, Allen County No. 539 (NBI: 0200269). Designed a similar bridge for Combs Street, Allen County No. 537 (NBI: 0200267).
Kellam, Fred, ISHC head of Bureau of Materials, Engineer of Design, Chief Bridge Engineer, Chief Engineer, Indianapolis, Indiana	Statewide	1919-1950s	Metal and concrete bridges	
Kennedy, A.M. and Family, Rush County, Indiana	Southeastern Indiana	1870-1918	Timber-covered bridges	Three generations of Kennedy-constructed bridges in Indiana; peak production was in 1880-85.
Kessler, George, landscape architect and bridge designer	Nationwide, Indianapolis and Terre Haute, Indiana	1908-1923	Concrete arch bridges	Nationally known landscape architect who designed bridges for the Indianapolis park and boulevard system, and subsequent plans for South Bend, Fort Wayne, and Terre Haute.

Table 2 Engineers, Designers, and Builders				
Name of Bridge Engineer, Designer, or Construction Company, and Location	**Geographic Area of Work**	**Active Dates of Bridge Engineering, Design, or Construction**	**Bridge Type or Form**	**Notes**
Kilborn, Hiram L., Lafayette, Indiana	Tippecanoe County, Indiana	1860s-1870s	Timber-covered bridges	
King Iron Bridge and Manufacturing Company, Cleveland, Ohio	Nationwide	1871-1901	Metal truss	The largest highway bridge works in the country by the 1880s.
Klausmann, Henry W., County Surveyor, Marion County, Indiana	Marion County, Indiana	Early twentieth century	Masonry and concrete bridges	Designed several bridges in Indianapolis parkways.
Kress, Joseph, Montgomery County, Indiana	Montgomery and Tippecanoe Counties, Indiana	1860s	Timber-covered bridges and masonry abutments	
Lafayette Bridge Company, Lafayette, Indiana	Central and western Indiana	1889-1900	Metal truss	Bought by American Bridge Company in 1900.
Luten, Daniel B., designer, Lafayette, Indiana	Nationwide	1900-1932	Concrete bridges	Nationally renowned designing and consulting engineer who owned nearly 50 bridge patents by 1920. Taught at Purdue University and ran several bridge-building companies to support his design practice.
Massillon Bridge Company, Massillon, Ohio	Midwest United States	1869-1901	Timber-covered bridges and metal trusses	
McAnlis, C., City Engineer, Fort Wayne, Indiana	Statewide	Early to mid-twentieth century	Concrete bridges	Designed Indiana's longest continuous T-beam structure in 1937, which the Portland Cement Association featured in an advertisement. (Carroll County No. 142, NBI: 0800105)
Miller, Charles W.	Jennings County, Indiana	Early twentieth century	Masonry arch	

Table 2 Engineers, Designers, and Builders				
Name of Bridge Engineer, Designer, or Construction Company, and Location	**Geographic Area of Work**	**Active Dates of Bridge Engineering, Design, or Construction**	**Bridge Type or Form**	**Notes**
Moore, William S., City Engineer, South Bend, Indiana; ISHC Chief Engineer, Indianapolis, Indiana	Statewide	1910s-1940	Concrete bridges	Designed several City Beautiful bridges in South Bend and Mishawaka, Indiana; was the first ISHC chief engineer; designed numerous significant bridges as a consulting engineer during the 1920s and 1930s.
National Bridge Company, Lafayette, Indiana and Los Angeles, California	Nationwide	Early twentieth century	Concrete bridges	Daniel Luten served as design consultant to Indiana company.
National Concrete Company, Indianapolis, Indiana	Statewide	Early twentieth century	Concrete bridges	Manufactured, contracted, and constructed Daniel Luten's bridges.
New Albany & Paoli Pike Company, Indiana	Statewide	1820s	Timber covered bridges	Built bridges for the early state road from New Albany to Paoli.
New Castle Bridge Company, New Castle, Indiana	Nationwide	1897-1905	Metal truss	
O'Conner, J.C.	Statewide	Early twentieth century	Masonry arch	
Pan-American Bridge Company, New Castle, Indiana	Nationwide	1902-1930s	Metal truss and metal beam	
Rights, W.H., City Engineer, ISHC Assistant Engineer, Columbus, Indiana	Statewide	1897-1910s	Concrete bridges	
Rochester Bridge Company, Rochester, Indiana	Nationwide, northern Indiana	1896-1901	Metal truss	Purdue connections stimulated experimentation with the fabrication of structural members.
Smith Bridge Company, Toledo, Ohio	Midwest United States	1870-1890	Timber-covered bridge, composite truss, and metal truss	

Table 2 Engineers, Designers, and Builders				
Name of Bridge Engineer, Designer, or Construction Company, and Location	**Geographic Area of Work**	**Active Dates of Bridge Engineering, Design, or Construction**	**Bridge Type or Form**	**Notes**
Smith, Robert W., Toledo, Ohio	Northern Indiana and Ohio	1867-1890s	Timber-covered bridges	Formed the Smith Bridge Company in Toledo, which later became Toledo Bridge Company. In 1867 Smith was granted a patent for a timber truss bridge.
Titus, William J., ISHC Chief Bridge Engineer, Indianapolis, Indiana	Statewide	1919-1933	Metal and concrete bridges	Chief Bridge Engineer and later Chief Engineer; wrote an essay on bridge aesthetics for George Hool's *Reinforced Concrete Construction*.
Toledo Bridge Company, Toledo, Ohio	Midwest United States	1890-1901	Metal truss	Successor to Smith Bridge Company.
Vincennes Bridge Company, Vincennes, Indiana	Southern Indiana	1899-1951	Metal truss	
Wabash and Erie Canal	Statewide	Nineteenth century	Masonry arch	Numerous stone arches built to carry the Wabash and Erie Canal over lateral streams.
Wabash Bridge and Iron Works, Wabash, Indiana	Nationwide	1895-1903	Metal truss	In 1900 the company had the second largest metal-fabricating plant in Indiana.
Washer, William T., Cannelton, Indiana	Southwestern Indiana	1866-1887	Timber-covered bridges	
Western Bridge Works, Fort Wayne, Indiana	Midwest United States	1877-1885	Iron truss	
Wheelock, Alpheus and Associates, Auburn, Indiana	Midwest United States, Northern Indiana	1869-1878	Timber-covered and metal bridges	Began as an agent for the Smith Bridge Company, formed the Wheelock Bridge Company and Western Bridge Company.
Wolf, Aaron and Henry, Putnam County, Indiana	Putnam and Parke Counties, Indiana	1838-1860s	Timber-covered bridges	
Wright, James E.	Ripley County, Indiana	Early twentieth century	Masonry arch	
Wrought Iron Bridge Company, Canton, Ohio	Midwest United States	1871-1900	Metal truss, Metal arch	

4. Summary Discussion of National Register Areas of Significance

This section summarizes the National Register areas of significance that relate to bridges built in Indiana through 1965, as outlined in *National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation* and *National Register Bulletin 16A: How to Complete the National Register Form*. This review provides a starting point for the development of National Register Criteria for Evaluation during the next stages of the inventory project.

Themes presented in the *Indiana Bridges Historic Context Study, 1830-1965* relate to more than one National Register area of significance. A theme is considered significant if it can be demonstrated to be important in American history. To qualify for the National Register, a property must be associated with a significant theme, and it must have the characteristics that make it a good representative of properties associated with that aspect of the past. Bridges may be considered for significance under one or more areas of significance or criteria. This summary is meant to introduce themes and areas of significance identified in this historic context that may be used during subsequent phases of the project.

The discussion is organized by associated National Register criterion.

Criterion A: Events – Properties that are associated with events that have made a significant contribution to the broad patterns of our history.

Criterion A recognizes bridges that have an important association with single events, a pattern of events, repeated activities, or historic trends that are significant within the context of Indiana's transportation and bridge-building history. Bridges may have an important association with an event or historic trend under Criterion A. It is important to note that significance under Criterion A requires a direct relationship between a bridge and an event or trend; an indirect or inferential relationship is not adequate to support significance under Criterion A.

Areas of significance under Criterion A include *Transportation*, which involves state transportation history and policy. Secondary areas of significance include *Commerce, Community Planning and Development, Social History, Agriculture,* and *Politics and Government.* Section 2 of this historic context introduces themes related to these areas of significance. One such theme is the development of important transportation routes, such as those that evolved from Native American trails, early state farm-to-market roads, the National Road or Dixie Highway.

Any bridge built within the subject period could be related to the areas of *Transportation* and/or *Politics and Government*. Generally, it is more common for urban bridges to be associated with *Commerce*, *Community Planning and Development*, and *Social History*, and rural bridges to be associated with *Agriculture*.

Criterion B: Persons – Properties that are associated with the lives of persons significant in our past.

Criterion B recognizes bridges that illustrate the important achievements of a person who was significant in Indiana's past. Structures must be compared to other properties associated with the work of the individual to identify those that best represent a person's historic contributions. Architects, artisans, artists, and engineers are often represented by their works, which are eligible under Criterion C. Therefore, the significant works of engineers or bridge-building companies are generally considered under Criterion C.

Criterion C: Design/Construction – Properties that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction.

Criterion C recognizes bridges that have distinctive design or construction characteristics that demonstrate the following: (1) the pattern of features common to a particular class of resources, (2) the individuality or variation of features that occurs within the class, (3) the evolution of that class of resources, and/or (4) the transition between classes of resources. Indiana bridges may have distinctive design or construction characteristics under Criterion C; therefore, bridges built within the subject period may be associated with the areas of significance *Engineering* and *Aesthetics.* Section 3.D of this historic context introduces bridge types, including some of the significant design and construction characteristics. Appendix B contains a preliminary analysis of extant Indiana bridge types.

Criterion C also recognizes bridges that are the work of a master or notable designer or builder. A master is a figure of recognized greatness in a field, a known craftsman of consummate skill, or an anonymous craftsman whose work is distinguishable from others by its style and quality. Bridges must express a particular phase in the development of the master's career, an aspect of his or her work, or a particular idea or theme in his or her craft. Sections 3.D and 3.E of this historic context identify notable bridge-building companies, engineers, and builders. Examples of master builders include Daniel B. Luten, who designed and patented an early twentieth-century reinforced concrete span, and George Kessler, who designed bridges for the Indianapolis parks and boulevard system.

Properties possessing high artistic values are also recognized under Criterion C. A bridge that fully articulates a particular concept of design so that it expresses an aesthetic ideal may be considered as possessing high artistic values. Section 3.D of this historic context identifies design details of specific bridge types, and Section 3.E addresses aesthetic ideals and bridge design through 1965. For example, bridges that epitomize the design principles of the Art Deco or Period Revival styles, discussed in Section 3.E, may be eligible under Criterion C.

Criterion D: Information Potential – Properties that have yielded, or may be likely to yield, information important in prehistory or history

Criterion D is most often applied to archaeological properties and it is highly unlikely that any Indiana bridges from the subject period would be eligible under Criterion D.

The National Register areas of significance provide a starting point for the future development of Criteria for Evaluation specific to Indiana's bridges during the next phases of the inventory project. Ideas presented in *Guidelines for Assessing the Cultural Significance of Indiana's Extant Metal Bridges (1872-1942)* and *Guidelines for Determining the Especially Significant Examples of Indiana's Extant Older Reinforced-Concrete Highway Bridges (1900-1942)* will also be considered in developing the methodology for stratifying the bridge population and the National Register evaluation criteria. In accordance with the PA, subsequent activities will include identifying historic bridges that are most suitable for preservation and are excellent examples of a given type of historic bridge.

Endnotes

[1] Donald F. Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II* ([Indianapolis, Ind.]: Indiana Historical Society, 1998), x-xi, 1-2.

[2] Herbert R. Hill, "America's First Union Station," *Outdoor Indiana* 39, (1975): 28.

[3] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 107.

[4] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 174-175, 192-193.

[5] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 234-237.

[6] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 450.

[7] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 141, 183-185.

[8] Linda Weintraut, *Resource Protection Planning Process: The Development of Transportation in Nine Counties of Northwestern Indiana, 1670-1890* (Indianapolis, Ind.: Department of History, Indiana University-Purdue University Indianapolis, 1991), 2-3.

[9] Rita W. Harlan, *Resource Protection Planning Process: The Development of Transportation in Ten Counties of Northeastern Indiana, 1670-1890* (Indianapolis, Ind.: Department of History, Indiana University-Purdue University Indianapolis, 1992), n.p.; Weintraut, *Resource Protection Planning Process: The Development of Transportation in Nine Counties of Northwestern Indiana, 1670-1890*, 10.

[10] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 39-41.

[11] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 39-41, 134-135.

[12] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 137-138.

[13] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 349-352.

[14] Glory-June Greiff, *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890* (Indianapolis, Ind.: Department of History, Indiana University-Purdue University Indianapolis, 1990), 35; Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 178.

[15] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 137-138, 178-179; Greiff, *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890*, 14; Ethel L. Montgomery, "The Building of the Michigan Road" (Thesis, Purdue University, 1902), 29.

[16] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 139-140.

[18] Lee Burns, *The National Road in Indiana*, vol. 7, no. 4, *Indiana Historical Society Publications* (Indianapolis, Ind.: C.E. Pauley & Co., 1919), 216.

[19] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 180.

[20] Greiff, *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890*, 16.

[21] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 139-140, 178; Burns, *The National Road in Indiana*, 234.

[22] A. T. Andreas, *Maps of Indiana Counties Together With the Plat of Indianapolis and a Sampling of Illustrations* ([Indianapolis, Ind.]: Indiana Historical Society, 1968), n.p.

[23] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 179.

[24] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 44, 136-137, 179.

[25] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 355.

[26] Greiff, *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890*, 16.

[27] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 355-357.

[28] Greiff, *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890*, 16.

[29] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 357; Greiff, *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890*, 21.

[32] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 240-241.

[33] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 347.

[34] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 144-145.

[36] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 181-182, 359; Emma L. Thornbrough, *Indiana in the Civil War Era, 1850-1880* (Indianapolis, Ind.: Indiana Historical Society, 1989), 323-325.

[37] Thornbrough, *Indiana in the Civil War Era, 1850-1880*, 323-325, 333, 336.

[38] Clifton J. Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920* (Indianapolis, Ind.: Indiana Historical Bureau & Indiana Historical Society, 1968), 230-233.

[39] Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 251-256.

[40] Thornbrough, *Indiana in the Civil War Era, 1850-1880*, 321-322; Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 262.

[41] Andreas, *Maps of Indiana Counties Together With the Plat of Indianapolis and a Sampling of Illustrations*, Map of Marion County.

[43] Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 364-365.

[44] Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 378-381, 383.

[45] Lance M. Neckar, "City Planning," in *American Landscape Architecture*, ed. William H. Tishler (Washington, D.C.: National Trust for Historic Preservation, 1989), 126.

[46] James L. Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942* (N.p.: James L. Cooper, 1997), 7, 9.

[47] Neckar, "City Planning," in *American Landscape Architecture,* 126.

[48] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 18-20, 22-23.

[49] Storrow Kinsella Associates, "Indianapolis Park and Boulevard System," National Register of Historic Places, National Park Service, 200413, 17-20; Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 24-26.

[50] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 26-30.

[51] Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 310-311; F. S. Chance, *The Official L.A.W. Road Book of Indiana: Containing Sectional Map of the Entire State* ([Indianapolis, Ind.]: Indiana Division, League of American Wheelman, 1896), n.p.

[54] Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 141; Bruce E. Seely, *Building the American Highway System: Engineers as Policy Makers* (Philadelphia, Penn.: Temple University Press, 1987), 15.

[55] Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 311.

[56] M. G. Lay, *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them* (New Brunswick, N.J.: Rutgers University Press, [1992]), 168.

[57] George E. Koster, *A Story of Highway Development in Nebraska*, Rev. ed. (Lincoln, Neb.: Nebraska Department of Roads, 1997), 7.

[58] Laurence I. Hewes and Clarkson H. Oglesby, *Highway Engineering* (New York: John Wiley & Sons, Inc., 1954), 3.

[59] Seely, *Building the American Highway System: Engineers as Policy Makers*, 24.

[60] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 110-111.

[61] National Park Service, *Lincoln Highway: Special Resource Study, Environmental Assessment* ([Washington, D.C.]: National Park Service, 2004), 32.

[62] Austin F. Bement, *The Lincoln Highway: Why it is, What it is, Where it is and How it is* (Detroit: Speaker-Hines Print Co., 1921), 2.

[63] Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 185; "Carl G. Fisher," Wikipedia, <http://en.wikipedia.org/wiki/Carl_G._Fisher> (accessed 7 August 2006).

[64] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 116; Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 184.

[65] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 110-111.

[66] Suzanne Fischer, "The Best Road South: The Failure of the Dixie Highway in Indiana," in *Looking Beyond the Highway: Dixie Roads and Culture*, ed. Claudette Stager and Martha Carver (Knoxville, Tenn.: University of Tennessee Press, 2006), 10. See also Indiana State Archives, Indiana State Highway Commission Records, Highway, Master Correspondence File – 84-1010, 1905-1980, Box 201, folders on named highways.

[68] Drake Hokanson, *The Lincoln Highway: Main Street Across America* (Iowa City, Iowa: University of Iowa Press, 1988), 11.

[69] Hokanson, *The Lincoln Highway: Main Street Across America*, 11.

[70] William Kaszynski, *The American Highway: The History and Culture of Roads in the United States* (Jefferson, N.C.: McFarland & Company, Inc., 2000), 38.

[71] Hokanson, *The Lincoln Highway: Main Street Across America*, 11.

[72] National Park Service, *Lincoln Highway: Special Resource Study, Environmental Assessment*, 3-5; James Lin, "The Lincoln Highway: An Introduction to America's First Transcontinental Road for the Automobile," California Institute of Technology, <http://www.ugcs.caltech.edu/~jlin/lincoln/> (accessed 14 September 2006).

[73] National Park Service, *Lincoln Highway: Special Resource Study, Environmental Assessment*, 3-5; Lin, "The Lincoln Highway: An Introduction to America's First Transcontinental Road for the Automobile," California Institute of Technology.

[74] Hokanson, *The Lincoln Highway: Main Street Across America*, 47-48; National Park Service, *Lincoln Highway: Special Resource Study, Environmental Assessment*, 11-12.

[75] Tom Anderson, "Hall County's Seedling Mile Holds Memories of Nation's First Transcontinental Highway," *Prairie Pioneer Press* 25, no. 10 (October 1991): n.p.

[76] *The Complete Official Road Guide of the Lincoln Highway* (Detroit, Mich.: The Lincoln Highway Association, 1916), 30.

[77] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 111.

[78] National Park Service, *Lincoln Highway: Special Resource Study, Environmental Assessment*, 12.

[79] Howard L. Preston, *Dirt Roads to Dixie* (Knoxville: University of Tennessee Press, 1991), 52-53.

[80] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 116; Fischer, "The Best Road South: The Failure of the Dixie Highway in Indiana," in *Looking Beyond the Highway: Dixie Roads and Culture,* 2; Martha Carver, "The Dixie Highway and Automobile Tourism in the South," *SCA Journal* 16, no. 2 (fall 1998): 22.

[81] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 116; Carver, "The Dixie Highway and Automobile Tourism in the South," *SCA Journal*, 22.

[82] See map of Dixie Highway in Phil T. Colgrove, "The Story of the Dixie Highway," *The Dixie Highway* (March 1925): 22.

[83] Carver, "The Dixie Highway and Automobile Tourism in the South," *SCA Journal*, 23.

[84] Fischer, "The Best Road South: The Failure of the Dixie Highway in Indiana," in *Looking Beyond the Highway: Dixie Roads and Culture,* 8-13.

[86] Colgrove, "The Story of the Dixie Highway," *The Dixie Highway*, 7.

[87] Seely, *Building the American Highway System: Engineers as Policy Makers*, 9.

[88] Federal Highway Administration, *America's Highways 1776-1976: A History of the Federal-Aid Program* (Washington, D.C.: United States Department of Transportation, Federal Highway Administration, 1977), 44.

[89] Seely, *Building the American Highway System: Engineers as Policy Makers*, 16-17.

[91] Seely, *Building the American Highway System: Engineers as Policy Makers*, 38.

[92] Seely, *Building the American Highway System: Engineers as Policy Makers*, 17.

[93] Seely, *Building the American Highway System: Engineers as Policy Makers*, 17.

[94] Seely, *Building the American Highway System: Engineers as Policy Makers*, 17.

[95] Seely, *Building the American Highway System: Engineers as Policy Makers*, 17.

[96] *Report of the Indiana Highway Commission (1914)* ([Indianapolis, Ind.]: 1914), 4-6.

[97] *Report of the Indiana Highway Commission (1914)*, 4-6.

[98] *Report of the Indiana Highway Commission (1914)*, 4-6. See also Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 116-117.

[99] *Laws of the State of Indiana (1917)* (Fort Wayne, Ind.: Fort Wayne Printing Company, 1917), 253-273; "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1917* ([Indianapolis, Ind.]: 1918), 480.

[100] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 119.

[101] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1917,* 481, 487.

[102] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1917,* 481-486.

[103] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 119-120.

[104] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 120; "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1918* (Indianapolis, Ind.: William B. Burford, 1919), 521-522.

[105] *Laws of the State of Indiana (1917)*, n.p.

[106] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1918,* 559; Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 120.

[107] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1918,* 569.

[108] Seely, *Building the American Highway System: Engineers as Policy Makers*, 17.

[109] Fifteenth Biennial Report of the Department of Public Works 1923-1924, 14.

[110] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1919* (Fort Wayne, Ind.: Fort Wayne Printing Company, 1920), 1147.

[111] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1927* (Indianapolis, Ind.: William B. Burford, 1928), 1174.

[112] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses* ([Indianapolis, Ind.]: State Highway Commission of Indiana, 1948), 31-32.

[113] Phillips, *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920*, 269; James H. Madison, *Indiana Through Tradition and Change: A History of the Hoosier State and its People, 1920-1945* (Indianapolis, Ind.: Indiana Historical Society, 1982), 186.

[114] Madison, *Indiana Through Tradition and Change: A History of the Hoosier State and its People, 1920-1945*, 186; Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 122.

[115] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1929* (Indianapolis, Ind.: William B. Burford, 1930), 1114.

[116] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1921* (Indianapolis, Ind.: William B. Burford, 1922), 1013.

[117] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1928* (Indianapolis, Ind.: William B. Burford, 1929), 1117.

[118] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1922* (Indianapolis, Ind.: William B. Burford, 1923), 1022; "Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1923* (Indianapolis, Ind.: William B. Burford, 1924), 1128; "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1927,* 1171-1172.

[119] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1927,* 1171-1172.

[120] Seely, *Building the American Highway System: Engineers as Policy Makers*, 89.

[121] Federal Highway Administration, *America's Highways 1776-1976: A History of the Federal-Aid Program*, 123; Seely, *Building the American Highway System: Engineers as Policy Makers*, 88-89.

[122] James S. Olson, ed., *Historical Dictionary of the New Deal* (Westport, Conn.: Greenwood Press, 1985), 369-370.

[123] James S. Olson, ed., *Historical Dictionary of the New Deal*, 398; Seely, *Building the American Highway System: Engineers as Policy Makers*, 90.

[124] James S. Olson, ed., *Historical Dictionary of the New Deal*, 177-178.

[125] James S. Olson, ed., *Historical Dictionary of the New Deal*, 83-84; Seely, *Building the American Highway System: Engineers as Policy Makers*, 90.

[126] James S. Olson, ed., *Historical Dictionary of the New Deal*, 548-551; Seely, *Building the American Highway System: Engineers as Policy Makers*, 90-91.

[127] United States Federal Works Agency, *Final Report on the WPA Program, 1935-43* (Washington, D.C.: GPO, 1947), 127.

[128] James S. Olson, ed., *Historical Dictionary of the New Deal*, 85-87.

[129] Seely, *Building the American Highway System: Engineers as Policy Makers*, 89-96.

[130] Seely, *Building the American Highway System: Engineers as Policy Makers*, 89-96.

[131] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1930* (Indianapolis, Ind.: William B. Burford, 1930), 1116.

[132] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1930,* 1116.

[133] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 124.

[134] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1931* (Indianapolis, Ind.: William B. Burford, 1932), 1076-1077.

[135] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 124.

[136] Madison, *Indiana Through Tradition and Change: A History of the Hoosier State and its People, 1920-1945*, 191; "Township Roads in Indiana Pass to County Control," *Engineering News-Record* 109, (1 September 1932): 267.

[137] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 32.

[138] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 32.

[139] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 26-27.

[140] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1933* (Indianapolis, Ind.: William B. Burford, 1934), 457-458.

[141] *Laws of the State of Indiana (1933)* (Fort Wayne, Ind.: Fort Wayne Printing Company, 1933), 78-79.

[142] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1934* (Indianapolis, Ind.: William B. Burford, [1935]), 623-625.

[143] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1934,* 623-625.

[144] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1935* (Reprint, Indianapolis, Ind.: [1936]), 3.

[145] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1935*, 3.

[146] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1931,* 1076-1077.

[147] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1935*, 27.

[148] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1934,* 624.

[149] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1935*, 4.

[150] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1936* (Indianapolis, Ind.: [1937]), 2-3.

[151] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1937* (Indianapolis, Ind.: William B. Burford, [1938]), 1.

[152] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1937,* 886.

[153] W. K. Hatt, "Joint Highway-Research Project Between Indiana State Highway Commission and Purdue University," in *Proceedings of the Twenty-Fourth Annual Road School Held at Purdue University, January 24-28, 1938*, ed. Ben H. Petty, vol. 22, no. 4, *Engineering Bulletin Purdue University, Extension Series no. 42, Engineering Extension Department* (Lafayette, Ind.: Purdue University, July 1938), 41-42.

[154] Kenneth B. Woods, "Aims and Activities of the Joint Highway Research Project: A Progress Report of an Investigation Conducted by the Engineering Experiment Station of Purdue University," *Engineering Bulletin Purdue University, Research Series Number 71, Engineering Experiment Station* (March 1940): 7-20.

[155] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1935*, 32.

[156] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1935*, 32.

[157] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1936*, 3.

[158] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1937,* 914.

[159] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1938* (Indianapolis, Ind.: William B. Burford, [1939]), 826.

[160] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1938,* 826.

[161] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1935*, 30.

[162] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1931,* 1077.

[164] State Highway Commission of Indiana, *Report of a Survey of Vehicular Traffic on the State and County Highways of Indiana, 1932-1933* ([Indianapolis, Ind.]: [1933]), 5-8.

[165] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1934,* 458.

[166] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Period Ended June 30, 1940* (Indianapolis, Ind.: [1941]), 43-44.

[167] Seely, *Building the American Highway System: Engineers as Policy Makers*, 166.

[168] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1936*, 27; "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1938,* 832-833; Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Period Ended June 30, 1940*, 43-44.

[169] Seely, *Building the American Highway System: Engineers as Policy Makers*, 176.

[170] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Period Ended June 30, 1941* (Indianapolis, Ind.: [1942]), 1060.

[171] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1942* (Indianapolis, Ind.: [1943]), 1-2.

[172] "Indiana to Start Defense Access Roads Construction," *Engineering News-Record* 126, (3 April 1941): 7.

[173] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1942*, 1-2; Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1942*, 1-2.

[174] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1942*, 1-2; Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1943* (Indianapolis, Ind.: [1944]), 43.

[175] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1943*, 1-2.

[176] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1944* (Indianapolis, Ind.: [1945]), 1-2; Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1945* (Indianapolis, Ind.: [1946]), 1-2.

[177] "State Highway Commission of Indiana," in *Year Book of the State of Indiana for the Year 1946* (Indianapolis, Ind.: [1947]), 1217-1219.

[178] "State Highway Commission of Indiana," in *Year Book of the State of Indiana for the Year 1946,* 1217-1219.

[179] Seely, *Building the American Highway System: Engineers as Policy Makers*, 189-191.

[180] "State Highway Commission of Indiana," in *Year Book of the State of Indiana for the Year 1947* (Indianapolis, Ind.: [1948]), 1112.

[181] A. E. Johnson, ed., *Published on the Occasion of the Golden Anniversary American Association of State Highway Officials: A Story of the Beginning, Purposes, Growth, Activities and Achievements of AASHO* (Washington, D.C.: The American Association of State Highway Officials, 1965), 153; Seely, *Building the American Highway System: Engineers as Policy Makers*, 191.

[182] "State Highway Commission of Indiana," in *Year Book of the State of Indiana for the Year 1948* (Indianapolis, Ind.: [1949]), 1105.

[183] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 2.

[184] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 1-36.

[185] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 37.

[186] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 37-43, 52-55, 72.

[187] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 100.

[188] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 101-109.

[189] Donald O. Covault, *Indiana's Highway Needs Study* (Lafayette, Ind.: Purdue University, 1957), n.p.; Joint Highway Research Project, *A Study of Highway Needs in Indiana* (Lafayette, Ind.: Purdue University, 1958), 1.

[190] Bridges on the Interstate Highway System are included in this inventory update process. However, properties on the Interstate Highway System are subject to the provisions of the Historic Preservation Exemption for the Interstate Highway System, which became effective on March 10, 2005. This exemption is included in Section 6007 of SAFETEA-LU re-authorization legislation.

[191] Seely, *Building the American Highway System: Engineers as Policy Makers*, 199-203.

[192] A. E. Johnson, ed., *Published on the Occasion of the Golden Anniversary American Association of State Highway Officials: A Story of the Beginning, Purposes, Growth, Activities and Achievements of AASHO*, 181; Tom Lewis, *Divided Highways: Building the Interstate Highways, Transforming American Life* (New York: Viking, 1997), 121; Richard F. Weingroff, "Federal-Aid Highway Act of 1956: Creating the Interstate System," Federal Highway Administration, <http://www.fhwa.dot.gov/infrastructure/rw96e.htm> (accessed 8 October 2004).

[193] Lay, *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them*, 98-99.

[194] Lay, *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them*, 317.

[195] James C. Creigh, "Constructing the Interstate Highway in Nebraska: Route and Funding Controversies," *Nebraska History* 72, no. 1 (spring 1991): 44.

[196] Lay, *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them*, 98-99.

[197] Weingroff, "Federal-Aid Highway Act of 1956: Creating the Interstate System," Federal Highway Administration.

[198] Lay, *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them*, 317.

[199] Seely, *Building the American Highway System: Engineers as Policy Makers*, 204.

[200] David A. Pfeiffer, "Ike's Interstate at 50: Anniversary of the Highway System Recalls Eisenhower's Role as Catalyst," *Prologue* 38, no. 2 (summer 2006): n.p.

[201] Robert A. Caro, *The Power Broker* (New York: Alfred A. Knopf, 1974), 921.

[202] A. E. Johnson, ed., *Published on the Occasion of the Golden Anniversary American Association of State Highway Officials: A Story of the Beginning, Purposes, Growth, Activities and Achievements of AASHO*, 181; Lewis, *Divided Highways: Building the Interstate Highways, Transforming American Life*, 121; Weingroff, "Federal-Aid Highway Act of 1956: Creating the Interstate System," Federal Highway Administration.

[203] Nebraska Department of Roads, *Second Biennial Report of the Department of Roads, 1959-1960* (Lincoln, Neb.: State of Nebraska Department of Roads, [1960]), 123; Nebraska Department of Roads, *Second Biennial Report of the Department of Roads, 1959-1960*, 123.

[204] Other than the change in the name and some administrative changes, the 1953 legislation left the agency largely as it was. In 1961 the legislature changed the name back to Indiana State Highway Commission. *Laws of the State of Indiana (1953)* (Fort Wayne, Ind.: Fort Wayne Printing Company, 1953), 816-819; Indiana State Highway Commission, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1961* ([Indianapolis, Ind.]: [1961]), 1.

[205] Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1956* ([Indianapolis, Ind.]: [1956]), 2-3; Brief History, 1-4.

[206] Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1959* ([Indianapolis, Ind.]: [1959]), introductory text, unpaginated; Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1962* ([Indianapolis, Ind.]: [1962]), 2; Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission for the Fiscal Year Ended June 30, 1963* ([Indianapolis, Ind.]: [1964]), 22.

[207] Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission for the Fiscal Year Ended June 30, 1963*, 22.

[209] Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission for the Fiscal Year Ended June 30, 1963*, 20.

[210] Indiana State Highway Commission, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1961*, Receipts & Disbursements; Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1965* ([Indianapolis, Ind.]: [1966]), 17.

[211] Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission for the Fiscal Year Ended June 30, 1963*, 16.

[212] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[213] Carmony, *Indiana, 1816-1850: The Pioneer Era - The History of Indiana Vol. II*, 180, 353.

[214] George E. Gould, *Indiana Covered Bridges Thru the Years* (Indianapolis, Ind.: Indiana Covered Bridge Society, Inc., 1977), 16-17.

[215] American Bar Association Committee No.106, "US Patent and Trademark Office General Information Concerning Patents," American Bar Association, <http://www.abanet.org/intelprop/comm106/106general.html> (accessed 30 August 2006); Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 91; Gould, *Indiana Covered Bridges Thru the Years*, 7.

[216] James L. Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930* ([Indianapolis, Ind.]: DePauw University et al, 1987), 22.

[217] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 22-23.

[218] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 91-96.

[219] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 26-30.

[220] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 100-106.

[221] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 100-106.

[222] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 116-119, 176-191.

[223] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 85-87.

[224] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 88-89.

[225] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 97.

[226] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1919,* 569, 571; "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1919,* 569.

[227] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 114.

[228] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 113.

[229] Seely, *Building the American Highway System: Engineers as Policy Makers*, 109-114.

[230] Seely, *Building the American Highway System: Engineers as Policy Makers*, 121-126.

[231] Seely, *Building the American Highway System: Engineers as Policy Makers*, 41-43.

[232] A. E. Johnson, ed., *Published on the Occasion of the Golden Anniversary American Association of State Highway Officials: A Story of the Beginning, Purposes, Growth, Activities and Achievements of AASHO*, 105.

[233] Seely, *Building the American Highway System: Engineers as Policy Makers*, 121-126.

[234] Seely, *Building the American Highway System: Engineers as Policy Makers*, 124.

[235] American Association of State Highway Officials, *A Policy on Grade Separations for Intersecting Highways* (Washington, D.C.: American Association of State Highway Officials, 1944), 43.

[236] American Association of State Highway Officials, *Policies on Geometric Highway Design* (Washington, D.C.: American Association of State Highway Officials, 1945), 4; George L. Carver, "The Interstate System Survey," in *Proceedings of the Twenty-Third Annual Short Course in Highway Engineering*, ed. Fred J. Benson (College Station, Tex.: Texas Engineering Experiment Station, A&M College of Texas, 1949), 54-55.

[237] Published on the Occasion of the Golden Anniversary American Association of State Highway Officials: A Story of the Beginning, Purposes, Growth, Activities and Achievements of AASHO (Washington, D.C.: American Association of State Highway Officials, 1957), xxiii; Ted Johnson, "Precast-Concrete Control Structures: Economical for an Irrigation District," *Civil Engineering* 32, no. 7 (July 1962): 105.

[238] American Association of State Highway Officials, *A Policy on Design Standards: Interstate System* (Washington, D.C.: American Association of State Highway Officials, 1959), 5-6.

[239] American Association of State Highway Officials, *Standard Specifications for Highway Bridges* (Washington, D.C.: American Association of State Highway Officials, 1957), xxiii.

[240] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, xxiii.

[241] American Association of State Highway Officials, *Standard Specifications for Highway Bridges* (Washington, D.C.: American Association of State Highway Officials, 1961), n.p.

[242] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, 9th ed. (Washington, D.C.: American Association of State Highway Officials, 1965), 502.

[243] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 100-106; *Laws of the State of Indiana (1917)*, 258-259.

[244] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1917,* 486.

[245] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1918,* 522.

[246] *Laws of the State of Indiana (1919)* (Fort Wayne, Ind.: Fort Wayne Printing Company, 1919), 126.

[247] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1918,* 571.

[248] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1919,* 1153.

[249] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1920* (Fort Wayne, Ind.: Fort Wayne Printing Company, 1921), 1021-1023.

[250] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1921,* 975-976.

[251] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1921,* 975-976.

[252] "Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1923,* 1168, 1197, Table IX.

[253] "Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1923,* 1165-1166.

[254] "Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1923,* 1166.

[255] "Seventh Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1925* (Indianapolis, Ind.: William B. Burford, 1925), 1049.

[256] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 150.

[257] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 150.

[258] "Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1923,* 1165.

[259] "Sixth Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1924* (Indianapolis, Ind.: William B. Burford, 1925), 1071.

[260] Warren T. Hobson, interview by Mead & Hunt, Mitchell, Ind., 7 September 2006.

[261] Denzil Doggett, "Engineers Play Active Part in CCC Work in Indiana," *Engineering News-Record* 114, (16 May 1935): n.p.; Glory June, *The Works Progress Administration: WPA, the Legacy of New Deal Work Programs in Indiana* (Indianapolis, Ind.: Indiana Committee for the Humanities, 1982), n.p.; Greiff, *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890*, n.p; Greiff, *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890*, n.p.

[262] "Report of the Indiana State Highway Commission," in *Year Book of the State of Indiana for the Year 1932* (Indianapolis, Ind.: William B. Burford, 1933), 496.

[263] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1936*, 28.

[264] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1936*, 2; "Obsolete Bridges on State Highways Factor in Safety," [Indianapolis, Ind.], 1939; "State's County Bridges and Culverts Major Problem for Road Officials," *Indianapolis Star*, 30 November 1941, n.p.

[265] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Period Ended June 30, 1939* (Indianapolis, Ind.: [1940]), 747.

[266] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1936*, 30.

[267] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1936*, 27.

[268] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1942*, 39.

[269] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1945*, 1; "Bolstering Up Old Small Bridges," *Roads and Streets* 87, no. 11 (November 1944): 70-71.

[270] State Highway Commission of Indiana, *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses*, 78-82.

[271] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 196-197.

[272] Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1962*, 2.

[273] Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1956*, 2; Indiana State Highway Department, *Annual Report of the State Highway Department of the State of Indiana for the Fiscal Year Ended June 30, 1957* ([Indianapolis, Ind.]: [1958]), 2; Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1959*, 2.

[274] Woods, "Aims and Activities of the Joint Highway Research Project: A Progress Report of an Investigation Conducted by the Engineering Experiment Station of Purdue University," *Engineering Bulletin Purdue University, Research Series Number 71, Engineering Experiment Station*, 7.

[275] Woods, "Aims and Activities of the Joint Highway Research Project: A Progress Report of an Investigation Conducted by the Engineering Experiment Station of Purdue University," *Engineering Bulletin Purdue University, Research Series Number 71, Engineering Experiment Station*, 11.

[276] Woods, "Aims and Activities of the Joint Highway Research Project: A Progress Report of an Investigation Conducted by the Engineering Experiment Station of Purdue University," *Engineering Bulletin Purdue University, Research Series Number 71, Engineering Experiment Station*, 11, 21.

[277] Woods, "Aims and Activities of the Joint Highway Research Project: A Progress Report of an Investigation Conducted by the Engineering Experiment Station of Purdue University," *Engineering Bulletin Purdue University, Research Series Number 71, Engineering Experiment Station*, 22.

[278] D. G. Shurig, "Minor Maintenance of County Bridges," in *Highway Extension and Research Project for Indiana Counties, Engineering Bulletin Purdue University, County Highway Series no. 7* (Lafayette, Ind.: Purdue University, August 1964), n.p.

[279] Charles Felkner, "Parke County Covered Bridges Thematic Resource," National Register of Historic Places, National Park Service, 1978.

[280] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[281] "Report of the Research and Extension Activities of the Engineering Schools and Departments for the Sessions of 1935-1936," *Engineering Bulletin Purdue University, Research Series Number 55, Engineering Experiment Station* 20, no. 5 (September 1936): 13-15.

[282] State Highway Commission of Indiana, *Standard Specifications for Bridge Construction* ([Indianapolis, Ind.]: State Highway Commission of Indiana, 1936), 226.

[283] Sheila R. Duwadi and Michael A. Ritter, "Timber Bridges in the United States," *Public Roads* 60, no. 3 (winter 1997): 5.

[284] "The Old National Bridge: Over the White Water River at Richmond, Ind.," *Proceedings of the Purdue Society of Civil Engineering* (1897): 61-63; Indiana Historical Bureau, "Covered Bridges in Indiana," *Indiana History Bulletin* 69, no. 1 (March 1998): n.p.

[285] Gould, *Indiana Covered Bridges Thru the Years*, 10.

[286] Gould, *Indiana Covered Bridges Thru the Years*, n.p.. Indiana County History Preservation Society, "Bell Ford Covered Bridge," Indiana County History Preservation Society, <http://www.countyhistory.com/coveredbridge/jackson1.htm> (accessed 18 July 2006); Indiana County History Preservation Society, "Covered Bridges of Indiana," Indiana County History Preservation Society, <http://www.countyhistory.com/coveredbridge/start.html> (accessed 6 July 2006).

[287] Indiana County History Preservation Society recognizes that 91 covered timber truss bridges are extant in Indiana. Indiana County History Preservation Society, "Covered Bridges of Indiana," Indiana County History Preservation Society.

[288] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[289] Gould, *Indiana Covered Bridges Thru the Years*, 16-17.

[290] Gould, *Indiana Covered Bridges Thru the Years*, 14.

[291] D. A. Gasparini, J. Bruckner, and F. da Porto, "Time-Dependent Behavior of Posttensioned Wood Howe Bridges," *Journal of Structural Engineering* 132, no. 3 (March 2006): 419; Gould, *Indiana Covered Bridges Thru the Years*, 8, 17-18, 29.

[292] Carl J. Heim, "The Construction of Small Treated-Timber Bridges in Dubois County, Indiana," in *Proceedings of the Twenty-Second Annual Road School Held at Purdue University, January 20-24, 1936*, ed. Ben H. Petty, vol. 20, no. 4, *Extension Series no. 37, Engineering Extension Department* (Lafayette, Ind.: Purdue University, July 1936), 68.

[293] Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1942*, 37; Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1943*, n.p.

[294] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[295] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[296] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[297] Parsons Brinckerhoff and Engineering and Industrial Heritage, *A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15* ([Washington, D.C.]: National Cooperative Highway Research Program, Transportation Research Board, 2005), 3.137-138.

[298] Doggett, "Engineers Play Active Part in CCC Work in Indiana," *Engineering News-Record*, 705.

[299] Dennis K. McDaniel, "Water Over Water: Hoosier Canal Culverts, 1832-1847," *Indiana Magazine of History* 78, no. 4 (December 1982): 296.

[300] McDaniel, "Water Over Water: Hoosier Canal Culverts, 1832-1847," *Indiana Magazine of History*, 296-307.

[301] Gould, *Indiana Covered Bridges Thru the Years*, 17.

[302] Jeffrey A. Hess and Robert M. Frame, III, *Historic Highway Bridges in Wisconsin: Volume 1, Stone and Concrete Arch Bridges* ([Madison, Wis.]: Wisconsin Department of Transportation, 1986), 16.

[303] S. S. Gorby, *Indiana Department of Geology and Natural Resources Seventeenth Annual Report* ([Indianapolis, Ind.]: Indiana Department of Geology and Natural Resources, 1891), n.p.

[304] "Value of Different Kinds of Stone Produced in 1894 and 1895," *Stone* 14, no. 3 (February 1897): 266-267.

[305] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[306] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[308] Doggett, "Engineers Play Active Part in CCC Work in Indiana," *Engineering News-Record*, 703-705.

[309] INDHPA database of National Register-listed bridges.

[310] James L. Cooper, "An Arch for All Seasons: From Culvert No. 100 to Burnett's Creek Arch," *Indiana Canals* 13, no. 1 (winter 2002): n.p.; McDaniel, "Water Over Water: Hoosier Canal Culverts, 1832-1847," *Indiana Magazine of History*, n.p.

[311] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[312] Gorby, *Indiana Department of Geology and Natural Resources Seventeenth Annual Report*, 27.

[313] George A. Hool and Frank C. Thiessen, *Reinforced Concrete Construction: Volume III, Bridges and Culverts* (New York: McGraw-Hill, 1916), 500.

[314] "Annual Meeting of the Indiana Engineering Society," *Engineering News* 45, no. 8 (21 February 1901): 141.

[315] Doggett, "Engineers Play Active Part in CCC Work in Indiana," *Engineering News-Record*, 705.

[316] Carl W. Condit, *American Building: Materials and Techniques from the First Colonial Settlements to the Present*, 2d ed. (Chicago: University of Chicago Press, 1982), 94; Carl W. Condit, *American Building: Materials and Techniques from the First Colonial Settlements to the Present*, *The Chicago History of American Civilization* (Chicago: University of Chicago Press, 1968), 94; Emory L. Kemp, "The Introduction of Cast and Wrought Iron in Bridge Building," *IA: The Journal of the Society for Industrial Archeology* 19, no. 2 (1993): 10.

[317] Kemp, "The Introduction of Cast and Wrought Iron in Bridge Building," *IA: The Journal of the Society for Industrial Archeology*, 5-10.

[318] "New Sullivan-Hutonsville Self-Anchoring Suspension Bridge Now in Use," *Indianapolis News*, 1 July 1941, n.p.

[320] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[322] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 48.

[323] Nathan W. Morgan, *Welded Bridge Construction* (Washington, D.C.: U.S. Department of Commerce, Bureau of Public Roads, [1957]), 1; H. M. Priest, "Strength of Structural Welds," *Engineering News-Record* 107, (17 September 1931): 436.

[324] Gilbert D. Fish, "First Arc-Welded Railway Truss Bridge," *Engineering News-Record* 101, (26 July 1928): n.p.

[325] State Highway Commission of Indiana, *Standard Specifications for Bridge Construction* ([Indianapolis, Ind.]: State Highway Commission of Indiana, 1939), 188.

[326] Robert Bettge, interview by Mead & Hunt, Indianapolis, Ind., 6 September 2006.

[327] T. R. Higgins and Mace H. Bell, "High-Strength Bolts - A New Structural Fastener," in *Proceedings of the Texas Structural Engineering Conference, March 21-22, 1952* (Austin, Tex.: The University of Texas, Department of Civil Engineering and Bureau of Engineering Research, [1952]), 28, 43, 47.

[328] Robert Bettge, interview by Mead & Hunt, Indianapolis, Ind., 6 September 2006.

[329] "Sixth Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1924,* 1166.

[331] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 52-54; Parsons Brinckerhoff and Engineering and Industrial Heritage, *A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15*, 3.22.

[332] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 64-65.

[333] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 67-68.

[334] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 70-73.

[335] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 76-77.

[336] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[338] Earl Feldman, "Design of Steel Bridges," in *Proceedings of the Seventeenth Annual Road School Held at Purdue University, January 19-23, 1931*, ed. Ben H. Petty, vol. 15, no. 2, *Engineering Bulletin Purdue University, Extension Series no. 26, Engineering Extension Department* (Lafayette, Ind.: Purdue University, March 1931), 116.

[339] Feldman, "Design of Steel Bridges," in *Proceedings of the Seventeenth Annual Road School Held at Purdue University, January 19-23, 1931,* 116.

[340] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 105.

[341] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 105-107, 273-274; Malverd A. Howe, "The Wabash River Bridge at Terre Haute, Indiana," *Engineering News* 55, no. 10 (8 March 1906): 273-275.

[342] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[343] "New Bridge Planned," *Indianapolis Star*, 23 December 1958, n.p.; "$14,000,000 Ohio River Span Opened to Traffic," *Indianapolis Star*, 23 December 1961, n.p.; Bill Wildhack, "Don't Quote Me," *Indianapolis News*, 18 December 1962, n.p.

[344] Fredric L. Quivik and Martin, Dale L., "Iron & Steel Bridges in Minnesota," National Register of Historic Places, National Park Service, 1989F-10.

[345] "Advertisement for United States Steel Sectional Plates," *Engineering News-Record* 125, (1 February 1940): n.p.; "Advertisement for United States Steel Sectional Plates," *Engineering News-Record* 126, (30 January 1941): n.p.

[346] H. D. Hartman, "Bridge Floor Specifications," in *Proceedings of the Fifteenth Annual Road School Held at Purdue University, January 21-25, 1929*, ed. Ben H. Petty, vol. 13, no. 2, *Engineering Bulletin Purdue University, Bulletin no. 20, Engineering Extension Department* (Lafayette, Ind.: Purdue University, May 1929), 16.

[347] J. C. Eckert, "Metal-Plate Pipe and Arches," in *Proceedings of the Twentieth Annual Road School Held at Purdue University, January 22-26, 1934*, ed. Ben H. Petty, vol. 18, no. 7, *Engineering Bulletin Purdue University, Extension Series no. 33, Engineering Extension Department* (Lafayette, Ind.: Purdue University, January 1934), 146-148.

[348] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 100-102.

[349] Cooper, *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930*, 104.

[350] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[351] *Handbook of Steel Drainage & Highway Construction Products*, 3rd ed. (Washington, D.C.: American Iron and Steel Institute, 1983), 13.

[352] "Advertisement for Granite City Steel Company Nu Arch Culverts," *Engineering News-Record* 125, (10 October 1940): n.p.

[353] "Iron-Plate Arch Reduces Load of Marshland Bridge," *Engineering News-Record* 115, no. 2 (11 July 1935): 41.

[354] "Quintuple Arch Bridge for Indiana County," *The Highway Magazine* (January 1940): 8-9.

[355] Joseph K. Shepard, "A Bridge to Safety," *Indianapolis Star Magazine* : 35.

[356] W. K. Hatt, "Current Research Work at Purdue," *Engineering News-Record* 115, (3 October 1935): 456-457.

[357] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[358] Henry G. Tyrrell, *Bridge Engineering* (Evanston, Ill.: 1911), 408.

[359] Parsons Brinckerhoff and Engineering and Industrial Heritage, *A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15*, 3.54; David Plowden, *Bridges: The Spans of North America* (New York: Viking Press, 1974), 298; Tyrrell, *Bridge Engineering*, 409-410.

[360] Parsons Brinckerhoff and Engineering and Industrial Heritage, *A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15*, 3.54-55.

[361] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 40-41; Parsons Brinckerhoff and Engineering and Industrial Heritage, *A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15*, 3.55.

[363] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 48-49.

[364] Kenneth Frampton, *Modern Architecture: A Critical History* (New York: Oxford University Press, 1980), 40.

[365] Hatt, "Current Research Work at Purdue," *Engineering News-Record*, 456-457; "Report of the Research and Extension Activities of the Engineering Schools and Departments for the Sessions of 1935-1936," *Engineering Bulletin Purdue University, Research Series Number 55, Engineering Experiment Station*, 17-18.

[366] Condit, *American Building: Materials and Techniques from the First Colonial Settlements to the Present*, 248-49.

[367] F. E. Musleh, "The Effects of Freezing and Thawing of Prestressed Concrete," in *Proceedings of the Forty-Fifth Annual Road School Held at Purdue University, March 30 - April 2, 1959*, ed. J. F. McLaughlin, vol. 44, no. 2, *Engineering Bulletin Purdue University, Extension Series no. 100, Engineering Extension Department* (Lafayette, Ind.: Purdue University, March 1960), 114-115.

[368] Robert Bettge, interview by Mead & Hunt, Indianapolis, Ind., 6 September 2006; John Samuelson, interview by Mead & Hunt, Indianapolis, Ind., 6 September 2006.

[369] "Odds and Ends," *Indianapolis News*, 6 November 1952, 43.

[370] American Association of State Highway Officials, *Standard Specifications for Highway Bridges*, xxiii.

[371] Tung Y. Lin and Felix Kulka, "Fifty-Year Advancement in Concrete Bridge Construction," *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers* 101, no. CO3 (September 1975): 494-495.

[372] Condit, *American Building: Materials and Techniques from the First Colonial Settlements to the Present*, 257.

[373] Lin and Kulka, "Fifty-Year Advancement in Concrete Bridge Construction," *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, 495.

[374] "Drivers to Benefit: Purdue Develops 1st U.S. Precast Bridge Deck," *Indianapolis News*, 20 October 1969, n.p.

[375] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[376] C. E. Drayer, "Concrete Bridges with Stone and Brick Facing," *Engineering News* 73, no. 25 (24 June 1915): 1214-1215.

[377] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 145.

[378] Parsons Brinckerhoff and Engineering and Industrial Heritage, *A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15*, 3.67.

[379] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 146, 148.

[380] William J. Titus, "An Attractive Concrete Bridge in Indiana," *The American City Magazine* 34, no. 5 (May 1926): 519-520.

[381] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 30-32.

[382] "Highway Arch Bridge of Plain Concrete Is Wholly Without Steel," *Concrete* 50, no. 8 (August 1942): 5-6; Samuel C. Hadden, "Highway Activities During and After the War," in *Proceedings of the Thirtieth Annual Road School Held at Purdue University, January 24-26, 1944*, vol. 28, no. 2, *Engineering Bulletin Purdue University, Extension Series no. 56, Engineering Extension Department* (Lafayette, Ind.: Purdue University, March 1944), 170; Indiana State Highway Commission, *Annual Report of the State Highway Commission of the State of Indiana for the Period Ended June 30, 1939*, 39; C. R. Ruminer, "Unreinforced Concrete Arches," *Roads and Streets* 85, no. 12 (December 1942): 27-28.

[384] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 156.

[385] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 169.

[386] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 166, 170.

[387] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[388] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p. This number eliminates bridges in the state and county bridge database that are catalogued as prestressed concrete structures with a year built prior to 1950, and a reconstruction date after 1965. Since prestressed concrete was not used as a bridge-building material until 1949, these bridges are assumed to have a prestressed concrete superstructure that postdates 1966.

[390] Norman L. Scott, "Suggestions for Reducing Costs in Prestressed Concrete Bridges," in *Highway Research Record Number 34: Bridge Design, Analysis, and Costs* (Washington, D.C.: Highway Research Board, 1963), 117.

[391] Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1959*, 66; Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1960* ([Indianapolis, Ind.]: [1960]), n.p.; Indiana State Highway Commission, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1961*, n.p.; Indiana State Highway Department, *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1962*, n.p.; Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission for the Fiscal Year Ended June 30, 1963*, n.p.; Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1964* ([Indianapolis, Ind.]: [1965]), n.p.; Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1965*, n.p.; Indiana State Highway Commission, *Annual Report of the Indiana State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1966* ([Indianapolis, Ind.]: [1967]), n.p.

[392] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p. This number eliminates bridges in the state and county bridge database that are catalogued as prestressed concrete structures with a year built prior to 1950, and a reconstruction date after 1965. Since prestressed concrete was not used as a bridge-building material until 1949, these bridges are assumed to have a prestressed concrete superstructure that postdates 1966.

[393] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 150-154.

[394] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[395] John Samuelson, interview by Mead & Hunt, Indianapolis, Ind., 6 September 2006.

[397] *Safety Inspection of In-Service Bridges: Participant Notebook*, vol. 1-2 ([McLean, Va.]: U.S. Dept. of Transportation, Federal Highway Administration, National Highway Institute, 1992), 8.10.3.

[398] John Samuelson, interview by Mead & Hunt, Indianapolis, Ind., 6 September 2006; Robert F. Butler, "New Howard County Bridge Will Replace 84-Year-Old Structure," *Indiana Consulting Engineer* (March 1960): 5.

[400] Indiana Department of Transportation, *County and State Bridge Inventory Database*, n.p.

[401] "Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1919,* 571.

[402] Charles H. Hoyt and William H. Burr, *Highway Bridges and Culverts*, *U.S. Department of Agriculture, Office of Public Roads - Bulletin No. 39* (Washington, D.C.: Government Printing Office, 1911), 15.

[403] "Sixth Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1924,* 1166; "Seventh Annual Report of the State Highway Commission," in *Year Book of the State of Indiana for the Year 1925,* 1049-1050.

[404] Hadden, "Highway Activities During and After the War," in *Proceedings of the Thirtieth Annual Road School Held at Purdue University, January 24-26, 1944,* 170.

[406] Shepard, "A Bridge to Safety," *Indianapolis Star Magazine*, 35.

[407] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 7-33.

[408] Condit, *American Building: Materials and Techniques from the First Colonial Settlements to the Present*, 251.

[409] Cooper, *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942*, 66, 72-73.

[410] Hool and Thiessen, *Reinforced Concrete Construction: Volume III, Bridges and Culverts*, 509-510.

[411] Frampton, *Modern Architecture: A Critical History*, 222-223.

[412] Elizabeth B. Mock, *The Architecture of Bridges* (New York: The Museum of Modern Art, 1949), 9.

[413] Frampton, *Modern Architecture: A Critical History*, 288.

Bibliography

"11 Miles of Interstate Designed in 16 Weeks." *Engineering News-Record* 161, no. 13 (25 September 1958): 42-48.

"390 Grade Crossings Eliminated from Federal Highways in 1928." *Engineering News-Record* 103 (1 August 1929): 172.

"1940 Road Allotments Announced by PRA." *Engineering News-Record* 124, no. 1 (4 January 1940): 25, 27.

"$14,000,000 Ohio River Span Opened to Traffic." *Indianapolis Star.* 23 December 1961. Available at Indiana State Library, Indiana Clipping File: Bridges 1960-1969, Indianapolis, Ind.

"A. A. Potter Made President of American Engineering Council." *Engineering News-Record* 116 (16 January 1936): 107.

"Action by the State Highway Officials." *Engineering News-Record* 79, no. 24 (13 December 1917): 1087.

"Active Bridge-Building." *Engineering News-Record* 104 (6 February 1930): 215-16.

"Advances in Highway Bridge Design Noted." *Engineering News-Record* 124, no. 4 (8 February 1940): 2.

"Advertisement for Granite City Steel Company Nu Arch Culverts." *Engineering News-Record* 125 (10 October 1940): 115.

"Advertisement for United States Steel Sectional Plates." *Engineering News-Record* 126 (30 January 1941): 77.

"Advertisement for United States Steel Sectional Plates." *Engineering News-Record* 125 (1 February 1940): 75.

"Advisory Board for Each State Announced by PWA." *Engineering News-Record* 111 (3 August 1933): 147.

Agg, Thomas R. "Federal Aid for Roads: Why Past Accomplishment Urges its Continuance." *Engineering News-Record* 104 (2 January 1930): 21-23.

"Albert Reichmann Retires From American Bridge." *Engineering News-Record* 120 (6 January 1938): 5.

Allen, G. H. "Modified Bailey Bridge Trusses Provide Temporary River Crossing." *Engineering News-Record* 137, no. 12 (19 September 1946): 368-69.

American Association of State Highway Officials. *Policies on Geometric Highway Design.* Washington, D.C.: American Association of State Highway Officials, 1945.

-----. *A Policy on Design Standards: Interstate System.* Washington, D.C.: American Association of State Highway Officials, 1959.

-----. *A Policy on Geometric Design of Rural Highways.* Washington, D.C.: American Association of State Highway Officials, 1965.

-----. *Standard Specifications for Highway Bridges (1949).* 5th ed. Washington, D.C.: American Association of State Highway Officials, 1949.

-----. *Standard Specifications for Highway Bridges (1953).* 6th ed. Washington, D.C.: American Association of State Highway Officials, 1953.

-----. *Standard Specifications for Highway Bridges (1957).* Washington, D.C.: American Association of State Highway Officials, 1957.

-----. *Standard Specifications for Highway Bridges (1961).* Washington, D.C.: American Association of State Highway Officials, 1961.

-----. *Standard Specifications for Highway Bridges (1965).* 9th ed. Washington, D.C.: American Association of State Highway Officials, 1965.

American Bar Association Committee No. 106. "US Patent and Trademark Office General Information Concerning Patents." American Bar Association. <http://www.abanet.org/intelprop/comm106/106general.html>.

Analysis of Rigid Frame Concrete Bridges. 4th ed. Chicago: Portland Cement Association, n.d.

Anderson, Tom. "Hall County's Seedling Mile Holds Memories of Nation's First Transcontinental Highway." *Prairie Pioneer Press* 25, no. 10 (October 1991).

Andreas, A. T. *Maps of Indiana Counties Together With the Plat of Indianapolis and a Sampling of Illustrations.* [Indianapolis, Ind.]: Indiana Historical Society, 1968.

"Annual Convention of the Indiana Engineering Society." *Engineering News* 67 (1 February 1912): 224.

"Annual Convention of the Indiana Engineering Society." *Engineering News* 55, no. 4 (25 January 1906): 108-9.

"Annual Meeting of the Indiana Engineering Society." *Engineering News* 41, no. 5 (2 February 1899): 79.

"Annual Meeting of the Indiana Engineering Society." *Engineering News* 43, no. 6 (8 February 1900): 104.

"Annual Meeting of the Indiana Engineering Society." *Engineering News* 45, no. 8 (21 February 1901): 140-141.

"Annual Meeting of the Indiana Engineering Society." *Engineering News* 47, no. 6 (6 February 1902): 124.

"Annual Meeting of the Indiana Engineering Society." *Engineering News* 49, no. 4 (22 January 1903): n.p.

"Annual Meeting of the Indiana Engineering Society." *Engineering News* 61 (21 January 1909): 77.

"Annual Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1923.* Indianapolis, Ind.: William B. Burford, 1924.

Arnold, Ethan L. "Road Law Procedure in the State of Indiana: A Paper Presented at the Eleventh Annual Road School Held at Purdue University January 19-23, 1925." *Bulletin of Purdue University Engineering Extensive Service* Circular No. 7 (1925): 3-21.

Ashton, Ned L. "First Welded Aluminum Girder Bridge Spans Interstate Highway in Iowa." *Civil Engineering* 28 (October 1958): 79-80.

Baas, Christopher, Tina Jones, and Malcolm Cairns. "The Civilizing of a Midwestern City: The Park and Boulevard System of Fort Wayne, Indiana - A Plan for the Ideal Development of Transportation, Parks, and Residential Subdivisions." National Register of Historic Places, National Park Service, [2005]. Available at Indiana Department of Natural Resources, Division of Historic Preservation and Archaeology.

Barnett, Joseph. "Road Design: Some Modern Aspects." *Traffic Engineering* 34, no. 4 (January 1964): 22, 79.

"Beam Connection Tests Discussed at Welding Meeting." *Engineering News-Record* 104 (1 May 1930): 727-28.

Becker, Donald N. "Research and Bridges." *Midwest Engineer* 15, no. 9 (May 1963): 10-11.

Bedford Quarries Company. "Advertisement for Bedford Stone." *Stone* 14, no. 6 (May 1897).

"Behind in Bridge Welding." *Engineering News-Record* 116 (14 May 1936): 712-13.

"The Bellefield Arch Bridge, in Schenley Park, Pittsburg, PA." *Engineering News* 41 (22 June 1899): 391-92.

"Belt-Line Defense Road Planned for Indianapolis." *Engineering News-Record* 127 (25 December 1941): 913.

Bement, Austin F. *The Lincoln Highway: Why it is, What it is, Where it is and How it is.* Detroit: Speaker-Hines Print Co., 1921.

Bennett, Pamela J. and Shirley S. McCord. *Progress After Statehood: A Book of Readings.* Vol. 49, *Indiana Historical Collections.* [Indianapolis, Ind.]: Indiana Historical Bureau, 1974.

"Bethlehem Steel Company." Bethlehem, PA Online. <http://www.bethlehempaonline.com/bethsteel.html>.

"Bills for Local Tax Relief Considered by Indiana Legislature." *Engineering News-Record* 109 (21 July 1932): 89.

Black, Michael S. *Reinforced Concrete Girder Bridge Study: Final Report.* West Lafayette, Ind.: Purdue University, 1978.

Blatchley, W. S. *Indiana Department of Geology and Natural Resources Twenty-First Annual Report.* Indianapolis, Ind.: William B. Burford, 1896.

-----. *Indiana Department of Geology and Natural Resources Twenty-Second Annual Report.* Indianapolis, Ind.: William B. Burford, 1897.

Blunk, H. A. "Construction of Small Bridges and Culverts by the County Maintenance Department." In *Proceedings of the Twelfth Annual Road School Held at Purdue University, January 18 to 22, 1926.* Edited by Ben H. Petty. Vol. 10, no. 2, *Engineering Bulletin Purdue University, Bulletin No. 14, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1926.

Boatright, William. "Specifications Needed in Repair and Maintenance of Roads and Bridges." In *Proceedings of the Thirty-Seventh Annual Road School Held at Purdue University, March 26-29, 1951.* Edited by Ben H. Petty. Vol. 36, no. 1, *Engineering Bulletin Purdue University, Extension Series No. 77, Engineering Extension Department.* Lafayette, Ind.: Purdue University, January 1952.

Bobbitt, A. N. "The Collection and Distribution of Gasoline Tax." In *Proceedings of the Fifteenth Annual Road School Held at Purdue University, January 21-25, 1929.* Edited by Ben H. Petty. Vol. 13, no. 2, *Engineering Bulletin Purdue University, Bulletin No. 20, Engineering Extension Department.* Lafayette, Ind.: Purdue University, May 1929.

"Bolstering Up Old Small Bridges." *Roads and Streets* 87, no. 11 (November 1944): 70-71.

Bowman, Waldo G. "Bridge Design and Construction." *Engineering News-Record* 126 (13 February 1941): 90-91.

-----. "Bridges and Buildings." *Engineering News-Record* 124 (15 February 1940): 73-75.

Brennan, John G. "Crossing Elimination." *Engineering News-Record* 118 (4 February 1937): 200-202.

"Bridge Across White River at Hazelton, Indiana." *Engineering News-Record* 92 (3 January 1924): 19.

Bridge Aesthetics Around the World. Washington, D.C.: National Research Council, Transportation Research Board, 1991.

"Bridge Building on an Indiana State Highway." *Engineering News-Record* 94, no. 20 (14 May 1925): 804-6.

"Bridge Building on Indiana State Highways in 1924." *Indiana Highways and Motors* 2, no. 3 (April 1924): 21-22.

"Bridge Built of Structural Scrap." *Engineering News* 73, no. 6 (11 February 1915): 272.

"Bridge Floor Built of Precast Concrete Slabs Secured by Welding." *Engineering News-Record* 106 (28 May 1931): 894.

"Bridge Handrails." *Engineering News-Record* 127 (24 July 1941): 4.

"Bridge History." *Engineering News-Record* 107 (17 September 1931): 434.

"A Bridge Sidewalk Failure Due to Paving Expansion." *Engineering News* 73, no. 2 (14 January 1915): 92-93.

"Bridges." In *Revised Statutes of the State of Indiana.* Vol. II, Chicago: E.B. Myers & Company, 1888.

"Bridges and Buildings." *Engineering News-Record* 122 (2 February 1939): 66.

"Bridges: Indianapolis." *Engineering News* 33 (3 January 1895). Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

"Brief History of the Direct Federal Highway Construction Program." Federal Highway Administration. <http://www.fhwa.dot.gov/infrastructure/blazer01.htm>.

"Brief News." *Engineering News-Record* 105 (4 December 1930): 901.

"Briefed Information on Concrete Behavior." *Engineering News-Record* 96, no. 7 (18 February 1926): 290.

Bruce, A. G. "The Effect of Increased Speed of Vehicles on the Design of Highways." *Public Roads* (March 1929): 11, 19-20.

Bryla, Stefan. "The First Arc-Welded Bridge in Europe." *Engineering News-Record* 104 (17 April 1930): 644-45.

Buerkle, Arthur. "Cleaning and Straightening Waterways at Bridges and Culverts (Tippecanoe County, Indiana)." In *Proceedings of the Twenty-Fifth Annual Road School Held at Purdue University, January 23-27, 1939.* Edited by Ben H. Petty. Vol. 23, no. 4, *Engineering Bulletin Purdue University, Extension Series No. 44, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1939.

"Build Roads!" *Engineering News-Record* 79, no. 3 (19 July 1917): 98.

Burch, A. V. "Press Release – At Will." Indianapolis, Ind.: 1921. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind. Copied from the Indiana State Highway Commission General Correspondence files at the Indiana State Archives, Indianapolis, Ind.

Burkey, J. R. "5...Bridge Design." *Engineering News-Record* 114 (17 January 1935): 90-94.

-----. "Highway Bridges – A Major Problem." In *Proceedings of the Twenty-Third Annual Road School Held at Purdue University, January 25-29, 1937.* Edited by Ben H. Petty. Vol. 21, no. 3, *Engineering Bulletin Purdue University, Extension Series No. 39, Engineering Extension Department.* Lafayette, Ind.: Purdue University, May 1937.

Burns, Lee. *The National Road in Indiana.* Vol. 7, no. 4, *Indiana Historical Society Publications.* Indianapolis, Ind.: C.E. Pauley & Co., 1919.

Burroughs, Edward A. "Fifty-Year Development Construction of Steel Girder Bridges." *Journal of the Construction Division, American Society of Civil Engineers* 101, no. C03 (September 1975): 463-75.

Butler, Robert F. "New Howard County Bridge Will Replace 84-Year-Old Structure." *Indiana Consulting Engineer* (March 1960): 5.

California Division of Highways. *Manual of Bridge Design Practice.* 2d ed. [Sacramento, Calif.]: State of California Highway Transportation Agency, Department of Public Works, Division of Highway, Bridge Department, 1963.

"Calumet River Improvement." *Engineering News-Record* 123 (23 November 1939): 686.

"Canalization of the Ohio." *Engineering News-Record* 103 (24 October 1929): 638-39.

"Carl G. Fisher." Wikipedia. <http://en.wikipedia.org/wiki/Carl_G._Fisher>.

Carmony, Donald F. *Indiana, 1816-1850: The Pioneer Era – The History of Indiana Vol. II.* [Indianapolis, Ind.]: Indiana Historical Society, 1998.

Caro, Robert A. *The Power Broker.* New York: Alfred A. Knopf, 1974.

Carver, Martha. "The Dixie Highway and Automobile Tourism in the South." *SCA Journal* 16, no. 2 (fall 1998): 22-23, 26.

Chance, F. S. *The Official L.A.W. Road Book of Indiana: Containing Sectional Map of the Entire State.* [Indianapolis, Ind.]: Indiana Division, League of American Wheelman, 1896.

"Changes Recommended for Indiana Highway Commission." *Engineering News-Record* 86 (10 April 1921): 443.

"A Cheap Concrete Steel Highway Bridge." *Engineering News* 48, no. 7 (14 August 1902): 114.

Chettoe, C. S. and Haddon C. Adams. *Reinforced Concrete Bridge Design.* 2d ed. London: Chapman & Hall, Ltd., 1946.

Chidsey, A. D. "Grade Crossing Elimination." *Engineering News* 61, no. 13 (1 April 1909): 348-49.

"City Cars Predominate on Indiana Roads." N.p.: n.d. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

"Civil Engineering and Construction in 1938: An Editorial Review." *Engineering News-Record* 122 (2 February 1939): 59-60, 66-68, 70.

Clark, Earl V. and Kendall Moultrop. "Load-Deformation Characteristics of Elastomeric Bridge Bearing Pads." *Highway Research Record*, no. 34 (1963): 90-91.

Clark, James G., ed. *Comparative Bridge Designs.* Cleveland, Ohio: The James F. Lincoln Arc Welding Foundation, May 1954.

-----. *Welded Interstate Highway Bridges.* Cleveland, Ohio: James F. Lincoln Arc Welding Foundation, January 1960.

Coffin, Ernest. "Benefits from a County Bridge Fund." In *Proceedings of the Thirty-Fifth Annual Road School Held at Purdue University, April 11-14, 1949.* Edited by Ben H. Petty. Vol. 33, no. 5, *Engineering Bulletin Purdue University, Extension Series No. 69, Engineering Extension Department.* Lafayette, Ind.: Purdue University, September 1949.

-----. "Repairing and Underpinning Bridge Abutments, Piers, and Retaining Walls." In *Proceedings of the Twenty-Ninth Annual Road School Held at Purdue University, January 25-27, 1943.* Edited by Ben H. Petty. Vol. 27, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 55, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1943.

Colgrove, Phil T. "The Story of the Dixie Highway." *The Dixie Highway* (March 1925): 1-3, 5-7.

The Complete Official Road Guide of the Lincoln Highway. Detroit, Mich.: The Lincoln Highway Association, 1916.

"Concrete Highway Bridge at Michigan City, Ind." *Engineering News-Record* 108 (16 June 1932): 874.

"Concrete Trestles Have I-Beams and Rails in Slabs." *Engineering News-Record* 79 (27 September 1917): 591-92.

Condit, Carl W. *American Building: Materials and Techniques from the First Colonial Settlements to the Present. The Chicago History of American Civilization.* Chicago: University of Chicago Press, 1968.

Continuous Concrete Bridges. 2d ed. Chicago: Portland Cement Association, n.d.

Continuous Hollow Girder Concrete Bridges. Chicago: Portland Cement Association, n.d.

"Continuous-Span Bridges and Structural Efficiency." *Engineering News-Record* 81, no. 8 (22 August 1918): 346-47.

"Continuous Structures." *Engineering News-Record* 102 (17 January 1929): 89.

Cooper, James L. "An Arch for All Seasons: From Culvert No. 100 to Burnett's Creek Arch." *Indiana Canals* 13, no. 1 (winter 2002): 1-14.

-----. *Artistry and Ingenuity in Artificial Stone: Indiana's Concrete Bridges, 1900-1942.* N.p.: James L. Cooper, 1997.

-----. *Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930.* [Indianapolis, Ind.]: DePauw University et al, 1987.

-----. "Notes on the *Hoosier State Automobile Association*." Indianapolis, Ind.: 1921. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind. Based on the Indiana State Highway Commission General Correspondence files found at the Indiana State Archives, Indianapolis, Ind.

-----. "Notes on the *Indiana Department of Geology and Natural Resources Seventeenth Annual Report, 1905*." Indianapolis, Ind.: 1906. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

-----. "Notes on the *Revised Statutes of the State of Indiana*." Indianapolis, Ind.: 1852. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

"County Unit Road Bond Petitions are Many in Indiana." *Engineering News-Record* 85 (8 July 1920): 93.

Covault, Donald O. *Indiana's Highway Needs Study.* Lafayette, Ind.: Purdue University, 1957.

Covault, Donald O. and Harold L. Michael. *Estimation of Highway Needs for County Primary Road Systems by Sample Survey Methods.* Lafayette, Ind.: Purdue University, 1959.

Crawford, Earl. "State Highway Problems and Plans." *Indiana Highways and Motors* 1 (July 1923): 9-14.

Creigh, James C. "Constructing the Interstate Highway in Nebraska: Route and Funding Controversies." *Nebraska History* 72, no. 1 (spring 1991): 44-53.

"Data on Motor Vehicle Registration in All States, with Average Revenue Per Vehicle." *Indiana Highways and Motors* 2, no. 3 (April 1924): 20-21.

Day, Leaton. "Cleaning and Painting Steel Bridges." In *Proceedings of the Twenty-Ninth Annual Road School Held at Purdue University, January 25-27, 1943.* Edited by Ben H. Petty. Vol. 27, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 55, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1943.

"Defense Priorities Included in Federal-Aid Highway Bill." *Engineering News-Record* 124 (27 June 1940): 4.

Degenkolb, Oris H. *Concrete Box Girder Bridges.* Ames, Iowa: The Iowa State University Press, 1977.

Deiss, Charles F. *Geologic Formations on Which and With Which Indian's Roads are Built. Indiana Geological Survey Circular No. 1.* Bloomington, Ind.: Geological Survey, Indiana Department of Conservation, 1952.

Derthick, Frank. "Indiana State Highway's Bridge Engineers (Design)." N.p.: 1987. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

Design and Control of Concrete Mixtures. 10th ed. Chicago: Portland Cement Association, 1952.

"The Disappearing Township Road." *Engineering News-Record* 162 (1 September 1932): 262.

"Distribution of Highway and Grade-Separation Funds Under Allotments Approved May 16, 1935." *Engineering News-Record* 114 (23 May 1935): 754.

Dodge, Martin. "The Government and Good Roads." *The Forum* 32 (February 1902): 292-97.

Doggett, Denzil. "Engineers Play Active Part in CCC Work in Indiana." *Engineering News-Record* 114 (16 May 1935): 703-5.

Drayer, C. E. "Concrete Bridges with Stone and Brick Facing." *Engineering News* 73, no. 25 (24 June 1915): 1214-15.

Dresser, George L. "Welded Highway Bridge Trusses of 150-Ft. Span." *Engineering News-Record* 116 (9 January 1936): 40-41.

"Drivers to Benefit: Purdue Develops 1st U.S. Precast Bridge Deck." *Indianapolis News.* 20 October 1969.

Dufour, F. O. "Increasing the Capacity of Framed Timber Joints." *Engineering News-Record* 110 (30 March 1933): 408-10.

Duwadi, Sheila R. and Michael A. Ritter. "Timber Bridges in the United States." *Public Roads* 60, no. 3 (winter 1997): 32-36. Available at Turner-Fairbank Highway Research Center website: http://www.tfhrc.gov/pubrds/winter97/p97wi32.htm.

Eckert, J. C. "Metal-Plate Pipe and Arches." In *Proceedings of the Twentieth Annual Road School Held at Purdue University, January 22-26, 1934.* Edited by Ben H. Petty. Vol. 18, no. 7, *Engineering Bulletin Purdue University, Extension Series No. 33, Engineering Extension Department.* Lafayette, Ind.: Purdue University, January 1934.

"An Editorial Survey: Bridges." *Engineering News-Record* 108 (4 February 1932): 134.

Edwards and Kelcey. "A Reconnaissance Study of Interstate Highways and Bridges in the Louisville-New Albany-Jeffersonville Metropolitan Area." Newark, N.J.: Edwards and Kelcey, 1958.

Edwards, Harlen H. "Skip-Span Concrete Arch Highway Bridge at Danville." *Engineering News-Record* 92 (22 May 1924): 896-98.

"Efficient Timber Jointing." *Engineering News-Record* 110 (30 March 1933): 417.

"Eight Toll Bridges Projected in Indiana." *Engineering News-Record* 98, no. 1 (27 September 1917): 36.

Elliot, Arthur. "Prestressed Concrete in California." *Highway Research Board Bulletin 144: Some Cost Data on Prestressed Concrete Bridges* (1956): 26-34.

"Engineering Schools and Colleges: Rose Polytechnic Institute." *Engineering News* 67 (27 June 1912): 27.

"ENR Construction Highest in History." *Engineering News-Record* 126 (13 February 1941): 132.

"Entire Road Program of Indiana County Abandoned." *Engineering News-Record* 108 (21 January 1932): 108.

Eriksen, E. L. "Concrete Bridges and Structures." *Engineering News-Record* 102 (16 May 1929): 801.

Evans, L. T. "Vierendeel Girder Bridge Introduced in America." *Engineering News-Record* 117 (1 October 1936): 471-72.

"Evansville Bridge Freed as Bonds are Retired." *Engineering News-Record* 126 (27 March 1941): 452.

"Failure of Concrete Arch Bridge Due to Pier Washout." *Engineering News-Record* 88 (8 June 1922): 951.

"The Failure of the Pugh Ford Arch Bridge." *Engineering News* 63, no. 16 (21 April 1910): 468-70.

Fairbank, H. S. "Trends of Highway Taxation with Special Reference to Property Taxes." In *Proceedings of the Thirtieth Annual Road School Held at Purdue University, January 24-26, 1944.* Vol. 28, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 56, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1944.

Faltus, Frantisek. "Welded Steel Arch of 166-ft. Span in Czechoslovakia." *Engineering News-Record* 113 (8 November 1934): 593.

"Federal Allocations Not Distributed by States." *Engineering News-Record* 111 (5 October 1933): 415.

"Federal Funds for New Road Projects Total $235,383,877." *Engineering News-Record* 106 (8 January 1931): 84.

Federal Highway Administration. "50th Anniversary Web Site: Frequently Asked Questions." Federal Highway Administration. <http://www.fhwa.dot.gov/interstate/faq.htm#question7>.

-----. *America's Highways 1776-1976: A History of the Federal-Aid Program.* Washington, D.C.: United States Department of Transportation, Federal Highway Administration, 1977.

-----. "The Dwight D. Eisenhower National System of Interstate and Defense Highways." Federal Highway Administration. <http://www.fhwa.dot.gov/reports/routefinder/>.

Feightner, Harold C. "Indiana County Government." *Indiana History Bulletin* 9, no. 6 (1932): 253-333.

Feldman, Earl. "Design of Steel Bridges." In *Proceedings of the Seventeenth Annual Road School Held at Purdue University, January 19-23, 1931.* Edited by Ben H. Petty. Vol. 15, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 26, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1931.

Felkner, Charles. "Parke County Covered Bridges Thematic Resource." National Register of Historic Places, National Park Service, 1978. Available at Indiana Department of Natural Resources, Division of Historic Preservation and Archaeology.

Ferguson, Phil M. *Reinforced Concrete Fundamentals with Emphasis on Ultimate Strength.* 2nd ed. New York: John Wiley & Sons, Inc., March 1966. Available at Environmental Affairs Division, Texas Department of Transportation, Austin, Tex.

"First Volume of New Taylor and Thompson." *Engineering News-Record* 95, no. 16 (15 October 1925): 642.

Fischer, Suzanne. "The Best Road South: The Failure of the Dixie Highway in Indiana." In *Looking Beyond the Highway: Dixie Roads and Culture.* Edited by Claudette Stager and Martha Carver. Knoxville, Tenn.: University of Tennessee Press, 2006.

Fish, Gilbert D. *Arc-Welded Steel Frame Structures.* New York: McGraw-Hill Book Company, Inc., 1933.

-----. "First Arc-Welded Railway Truss Bridge." *Engineering News-Record* 101 (26 July 1928): 120-123.

-----. "Specification for Arc-Welded Connections in Bridges." *Engineering News-Record* 103 (22 August 1929): 292-97.

"Flood Damage on Indiana Roads Will Cost $250,000." *Engineering News-Record* 118 (11 March 1937): 389.

"Flood Protection Works Progress at Peru, Ind." *Engineering News-Record* 95, no. 24 (10 December 1925): 962-63.

"Floods Break All Records in Lower Ohio Valley." *Engineering News-Record* 118 (28 January 1937): 142-43.

Florida Department of Transportation Environmental Management Office. *Historic Highway Bridges of Florida.* Tallahassee, Fla.: Florida Department of Transportation, 2004.

"Ford and the Highway." *Engineering News-Record* 99, no. 23 (8 December 1927): 906-7.

"Four Indiana Engineering Societies Meet Together." *Engineering News-Record* 80 (7 February 1918): 283.

Frampton, Kenneth. *Modern Architecture: A Critical History.* 3d ed. New York: Thames and Hudson, 1992.

"Gasoline Tax Nets Indiana $4,554,544." *Engineering News-Record* 93, no. 8 (21 August 1924): 298.

Gasparini, D. A., J. Bruckner, and F. da Porto. "Time-Dependent Behavior of Posttensioned Wood Howe Bridges." *Journal of Structural Engineering* 132, no. 3 (March 2006): 418-29.

Gatewood, Arthur. *Indiana Covered Bridge Location Guide.* Indianapolis, Ind.: Indiana Covered Bridge Society, 1988.

Gault, George F. "Design and Construction of a Concrete Arch Bridge." In *Proceedings of the Nineteenth Annual Road School Held at Purdue University, January 23-27, 1933.* Edited by Ben H. Petty. Vol. 16, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 30, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1933.

Gauvreau, Paul. *The Three Myths of Bridge Aesthetics.* N.p., n.d. Available at University of Toronto Department of Civil Engineering website: <http://www.civil.engineering.utoronto.ca/scripts/index_.asp>.

Gayler, Carl. "American Metal Bridges Fifty Years Ago." *Engineering News-Record* 95, no. 10 (3 September 1925): 385-86.

Gemeny, Albin L. "Bridge Engineering in 1937." *Engineering News-Record* 120 (10 February 1938): 233-34.

Gillin, P. R. "Grade Separation at New Carlisle, Ind." In *Proceedings of the Thirteenth Annual Road School Held at Purdue University, January 17-21, 1927.* Edited by Ben H. Petty. Vol. 11, no. 3, *Engineering Bulletin Purdue University, Bulletin No. 16, Engineering Extension Department.* Lafayette, Ind.: Purdue University, May 1927.

Gimsing, Niels J. *Cable Supported Bridges: Concept and Design.* 3d ed. New York: John Wiley & Sons, 1998.

"Girders Replace Trusses." *Engineering News-Record* 120 (19 May 1938): 707.

Godfrey, Edward. "The Design of Concrete-Steel Beams and Slabs." *Engineering News* 55, no. 11 (15 March 1906): 290.

"Good Progress made in Operation of Federal-Aid Road Act." *Engineering News-Record* 79, no. 25 (20 December 1917): 1148-50.

Gorby, S. S. *Indiana Department of Geology and Natural Resources Seventeenth Annual Report.* [Indianapolis, Ind.]: Indiana Department of Geology and Natural Resources, 1891.

Gould, George E. *Indiana Covered Bridges Thru the Years.* Indianapolis, Ind.: Indiana Covered Bridge Society, Inc., 1977.

"Grand Trunk Relocates its Line through South Bend, Ind." *Engineering News-Record* 103 (3 October 1929): 538-42.

Gregory, J. R. "Operations of a County Bridge Crew." In *Proceedings of the Nineteenth Annual Road School Held at Purdue University, January 23-27, 1933.* Edited by Ben H. Petty. Vol. 16, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 30, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1933.

Greiff, Glory-June. *Resource Protection Planning Process: The Development of Transportation in Eighteen Counties of Eastern and Central Indiana, 1670-1890.* Indianapolis, Ind.: Department of History, Indiana University-Purdue University Indianapolis, 1990.

Grover, LaMotte. "Arch-Welded Bridge Girders Tested to Failure." *Engineering News-Record* 115 (19 September 1935): 392-94.

-----. "Foreign Countries Lead U.S. in Welded Bridges." *Engineering News-Record* 116 (14 May 1936): 703-9.

-----. "How to Prepare Drawings for Structural Welding." *Engineering News-Record* 127 (28 August 1941): 70-72.

Grover, O. L. "War Brings Bridge Building Back to Early Practices." *Public Roads* 1 (August 1918): 18-19, 23, 27.

Hackedorn, H. F. "Three-Hinged Concrete Arch Bridge, Brookside Park, Cleveland, O." *Engineering News* 55, no. 19 (10 May 1906): 507, 517-18.

Hadden, Samuel C. "Highway Activities During and After the War." In *Proceedings of the Thirtieth Annual Road School Held at Purdue University, January 24-26, 1944.* Vol. 28, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 56, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1944.

-----. "Wartime Highway Improvement As Affected by Men, Materials, Machinery, and Money." In *Proceedings of the Twenty-Ninth Annual Road School Held at Purdue University, January 25-27, 1943.* Edited by Ben H. Petty. Vol. 27, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 55, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1943.

Hadley, W. W. "Bridge Surveys for New Structures." In *Proceedings of the Thirteenth Annual Road School Held at Purdue University, January 17-21, 1927.* Edited by Ben H. Petty. Vol. 11, no. 3, *Engineering Bulletin Purdue University, Bulletin No. 16, Engineering Extension Department.* Lafayette, Ind.: Purdue University, May 1927.

Hanapel, H. A. "Design and Construction of Six-Span Reinforced Concrete Highway Bridge Crossing Wabash River at Attica, Indiana." *Municipal and County Engineering* 63, no. 2 (August 1992): 37-44.

"Hard Roads, Marketable Produce." *Engineering News-Record* 79 (9 August 1917): 243.

Hardesty, Egbert R., Henry W. Fischer, and Richard W. Christie. "Fifty-Year History of Movable Bridge Construction – Part I." *Journal of the Construction Division, American Society for Civil Engineers* 101, no. C03 (September 1975): 511-27.

-----. "Fifty-Year History of Movable Bridge Construction – Part II." *Journal of the Construction Division, American Society for Civil Engineers* 101, no. C03 (September 1975): 529-43.

Harlan, Rita W. *Resource Protection Planning Process: The Development of Transportation in Ten Counties of Northeastern Indiana, 1670-1890.* Indianapolis, Ind.: Department of History, Indiana University-Purdue University Indianapolis, 1992.

-----. *Resource Protection Planning Process: The Development of Transportation in Ten Counties of Northeastern Indiana, 1890-1940.* Indianapolis, Ind.: Department of History, Indiana University-Purdue University Indianapolis, 1992.

Harris, George C. "Economy of Bridge Design." *Midwest Engineer* 12, no. 9 (April 1960): 12-14.

Harrison, Dawn M. "Structural Study of Reinforced Concrete Arch Bridges." In *Repairing and Restoring Historic Bridges: Keeping Faith with their Makers, a Workshop on 4 June 1998.* [Indianapolis, Ind.]: n.d.

Harrison, J. L. "Bridges Must Be Safe for Modern Highway Traffic." *Public Roads* 1 (December 1918): 34-36.

Hartman, H. D. "Bridge Floor Specifications." In *Proceedings of the Fifteenth Annual Road School Held at Purdue University, January 21-25, 1929.* Edited by Ben H. Petty. Vol. 13, no. 2, *Engineering Bulletin Purdue University, Bulletin No. 20, Engineering Extension Department.* Lafayette, Ind.: Purdue University, May 1929.

Hassan, Ahmed F. *Fatigue Strength of Girders with Tapered Cover Plates.* West Lafayette, Ind.: Joint Highway Research Project, Purdue University, 1995.

Hatt, W. K. "Current Research Work at Purdue." *Engineering News-Record* 115 (3 October 1935): 456-58.

-----. "Joint Highway-Research Project Between Indiana State Highway Commission and Purdue University." In *Proceedings of the Twenty-Fourth Annual Road School Held at Purdue University, January 24-28, 1938.* Edited by Ben H. Petty. Vol. 22, no. 4, *Engineering Bulletin Purdue University, Extension Series No. 42, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1938.

Hawley, H. H. and J. C. Merrell. "Lessons Learned in Welding a Steel-Plate Bridge Floor." *Engineering News-Record* 115 (3 October 1935): 472-74.

Hayden, Arthur G. "Continuous Frame Design Used for Concrete Highway Bridges." *Engineering News-Record* 90 (11 January 1923): 73-75.

"Hazards and Safeguards of Highway Structure." *Engineering News-Record* 94, no. 1 (1 January 1925): 15-20.

Heim, Carl J. "The Construction of Small Treated-Timber Bridges in Dubois County, Indiana." In *Proceedings of the Twenty-Second Annual Road School Held at Purdue University, January 20-24, 1936.* Edited by Ben H. Petty. Vol. 20, no. 4, *Extension Series No. 37, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1936.

"The Hell Gate Steel Arch Bridge." *Engineering News* 71, no. 2 (8 January 1914): 59-64.

Henry, J. M. *A Short History of the Indiana State Highway Commission.* Indianapolis, Ind., October 1926. Available at James Cooper's Files, Greencastle, Ind.

Herald, H. M. "Swamp Road Building Among the Indiana Sand Dunes." *Engineering News-Record* 92, no. 2 (10 January 1924): 58-60.

Herschell, William. "Indianapolis-Born Dixie Highway to Have its Tenth Anniversary Celebrated with Great Motorcade." *The Dixie Highway* (September 1925): 6-8.

Hess, Jeffrey A. and Robert M. Frame, III. *Historic Highway Bridges in Wisconsin: Volume 1, Stone and Concrete Arch Bridges.* [Madison, Wis.]: Wisconsin Department of Transportation, 1986.

-----. *Historic Highway Bridges in Wisconsin: Volume 3, Historical Survey of Wisconsin Movable Bridges, Part 1.* [Madison, Wis.]: Wisconsin Department of Transportation, 1996.

"Highway Accidents in Indiana." *Engineering News-Record* 104 (1 May 1930): 725.

"Highway Arch Bridge of Plain Concrete Is Wholly Without Steel." *Concrete* 50, no. 8 (August 1942): 5-6.

"Highway Bridge Construction Activity in 1925." *Engineering News-Record* 96 (14 January 1926): 79-83.

"Highway Bridge Construction Activity in 1925 (Concluded)." *Engineering News-Record* 96, no. 3 (21 January 1926): 122-24.

"Highway Bridge Damage in Indiana." N.p.: 1913. Available at James Cooper's Files, General Bridge File/Concrete Design & Construction (1910-1915), Greencastle, Ind.

"Highway Officials Report Progress." *Engineering News-Record* 119 (14 October 1937): 645-47.

"Highway Officials Stress Safety as Major Problem." *Engineering News-Record* 115 (4 February 1932): 891-94.

Hill, David Y. "The Architectural Design of Concrete Bridges." In *Highway Bridge Design.* London: Charles Griffen & Company Limited, 1948.

Hill, Herbert R. "America's First Union Station." *Outdoor Indiana* 39 (1975): 27-38. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

Hinkle, A. H. "Highway Development and its Problems in Indiana." *Roads and Streets* 69, no. 8 (August 1929): 281-83.

Hokanson, Drake. *The Lincoln Highway: Main Street Across America.* Iowa City, Iowa: University of Iowa Press, 1988.

Hool, George A. and Frank C. Thiessen. *Reinforced Concrete Construction: Volume III, Bridges and Culverts.* New York: McGraw-Hill, 1916.

Hoosier State Automobile Association, Hoosier Motor Club, and Indiana Auto Trade Association. "Advertisement to *The Automobile Owners and Dealers of Indiana*." N.p.: 1922. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

Hovey, Otis E. "Welded Structure Design for Dynamic Loads." *Engineering News-Record* 116 (27 February 1936): 310-12.

"How Shall Our Highways be Financed?" *Engineering News-Record* 94, no. 2 (8 January 1925): 73-77.

Howe, Malverd A. "The Wabash River Bridge at Terre Haute, Indiana." *Engineering News* 55, no. 10 (8 March 1906): 273-75.

Hulsbos, C. L. and D. A. Linger. "Dynamic Tests of a Three-Span Continuous I-Beam Highway Bridge." *Highway Research Board Bulletin 279: Bridge Design Studies and Piling Tests* (1960): 18-19.

Hunley, J. B. "Bridge of Unusual Design Replaces Ohio River Crossing of Big Four at Louisville." *Engineering News-Record* 103, no. 10 (5 September 1929): 358-62.

Ickes, Harold L. "Public Works in the Federal Service." *Engineering News-Record* 110 (18 May 1933): 613-17.

"Indiana 1922 Road Construction Mileage." *Engineering News-Record* 90 (8 February 1923): 263.

"Indiana Bridge 1923 Activities." *Engineering News-Record* 92 (1 May 1924): 759.

"Indiana County Highway Engineers Under New Licensing Law." *Engineering News-Record* 90, no. 2 (11 January 1923): 90.

Indiana County History Preservation Society. "Bell Ford Covered Bridge." Indiana County History Preservation Society. <http://www.countyhistory.com/coveredbridge/jackson1.htm>.

-----. "Covered Bridges of Indiana." Indiana County History Preservation Society. <http://www.countyhistory.com/coveredbridge/start.html>.

Indiana Covered Bridge Guide. [Indianapolis, Ind.]: Indiana Covered Bridge Society, Inc., 1980.

"Indiana Has $1,000,000 Highway Bridge Program." *Engineering News-Record* 94, no. 17 (23 April 1925): 706.

"Indiana Highway Bridge Construction." *Engineering News-Record* 90 (25 January 1923): 160.

"Indiana Highway Commission Appoints Engineer." *Engineering News-Record* 79, no. 3 (19 July 1917): 138.

"Indiana Highway Commission Engineer Dismissed." *Engineering News-Record* 95, no. 6 (6 August 1925): 234.

"Indiana Highway Commission Law Declared Constitutional." *Engineering News-Record* 82 (23 January 1919): 205.

"Indiana Highway Department Reorganized Under New Law." *Engineering News-Record* 111 (27 July 1933): 118.

"Indiana Highway Department Spreads Work by Shortening Day." *Engineering News-Record* 107 (22 October 1931): 667-68.

"Indiana Highway Mileage and Receipts." *Engineering News-Record* 111 (7 December 1933).

Indiana Historical Bureau. "Canal Construction in Indiana." *The Indiana Historian* (September 1997).

----. "Canal Mania in Indiana." *The Indiana Historian* (June 1997).

-----. "Covered Bridges in Indiana." *Indiana History Bulletin* 69, no. 1 (March 1998). Available at Indiana Historical Bureau website: <http://www.statelib.lib.in.us/www/ihb/publications/introcb.html>.

-----. "Footprints Across the Dunes." *The Indiana Historian* (December 1994).

Indiana Junior Historical Society and Society of Indiana Pioneers. *Water Crossings of Southeastern Indiana.* Indianapolis, Ind.: Indiana Junior Historical Society, 1973.

Indiana Lincoln Highway Commission. *Report of Lincoln Highway Commission to Governor Samuel M. Ralston, December 15, 1916.* [Indianapolis, Ind.]: N.p., 1916.

Indiana Lincoln Memorial Highway Commission. *The Lincoln Memorial Way Through Indiana, Report of Commission Appointed by Governor Harry G. Leslie to Designate Historic Lincoln Route.* [Indianapolis, Ind.], n.d.

"Indiana May Not Obtain Funds for Highway Work." *Engineering News-Record* 127 (6 November 1941): 634.

Indiana National Road Association. "History of the Road." Indiana National Road Association. <http://www.indiananationalroad.org/History.CFM>.

"Indiana Plans 20-Year Highway Program." *Engineering News-Record* 126 (13 February 1941): 212.

"Indiana Re-Allocates Cost of Grade Separation Work." *Engineering News-Record* 122 (6 April 1939): 467.

"Indiana Revamps and Refines." *Engineering News-Record* 124 (18 January 1940): 102.

"Indiana Road Commission Develops Post-War Plans." *Engineering News-Record* 127 (31 July 1941): 144.

"Indiana Road Head Tells of Superhighway Plan." *Engineering News-Record* 125 (28 November 1940): 2.

"Indiana Road Staff Cut in Economy Move." *Engineering News-Record* 122 (11 May 1939): 640.

"Indiana Road Work in 1927." *Engineering News-Record* 100 (5 January 1928): 31.

"Indiana Spending $5,000,000 on Roads." *Engineering News-Record* 83, no. 10 (4 September 1919): 488.

Indiana State Highway Commission. "Accomplishments and Costs." [Indianapolis, Ind.]: 1945. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1935.* Reprint, Indianapolis, Ind., [1936].

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1936.* Indianapolis, Ind., [1937].

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Period Ended June 30, 1939.* Indianapolis, Ind., [1940].

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Period Ended June 30, 1940.* Indianapolis, Ind., [1941].

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Period Ended June 30, 1941.* Indianapolis, Ind., [1942].

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1942.* Indianapolis, Ind., [1943].

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1943.* Indianapolis, Ind., [1944].

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1944.* Indianapolis, Ind., [1945].

-----. *Annual Report of the State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1945.* Indianapolis, Ind., [1946].

-----. *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1961.* [Indianapolis, Ind.], [1961].

-----. *Annual Report of the Indiana State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1964.* [Indianapolis, Ind.], [1965].

-----. *Annual Report of the Indiana State Highway Commission for the Fiscal Year Ended June 30, 1963.* [Indianapolis, Ind.], [1964].

-----. *Annual Report of the Indiana State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1965.* [Indianapolis, Ind.], [1966].

-----. *Annual Report of the Indiana State Highway Commission of the State of Indiana for the Fiscal Year Ended June 30, 1966.* [Indianapolis, Ind.], [1967].

-----. "Office Memorandum: Publicity." Indianapolis, Ind.: 1924. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind. Copied from the Indiana State Highway Commission General Correspondence files, Box 2, at the Indiana State Archives, Indianapolis, Ind.

-----. "Press Release - Afternoon Papers, Wednesday, May 10." Indianapolis, Ind.: 1921. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind. Copied from the Indiana State Highway Commission General Correspondence files at the Indiana State Archives, Indianapolis, Ind.

-----. "Press Release - At Will." Indianapolis, Ind.: 1921. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind. Copied from the Indiana State Highway Commission General Correspondence files at the Indiana State Archives, Indianapolis, Ind.

-----. "Press Release – Tuesday May 9." Indianapolis, Ind.: 1921. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind. Copied from the Indiana State Highway Commission General Correspondence files at the Indiana State Archives, Indianapolis, Ind.

-----. "Some Bridge Problems in Indiana." N.p.: 1923. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind. Copied from the Indiana State Highway Commission 1923 Correspondence files at the Indiana State Archives, Indianapolis, Ind.

"Indiana State Highway Commission Selects Chief Engineer." *Engineering News-Record* 82 (15 May 1919): 988.

Indiana State Highway Department. *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1953.* [Indianapolis, Ind.], [1953].

-----. *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1954.* [Indianapolis, Ind.], [1954].

-----. *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1955.* [Indianapolis, Ind.], [1955].

-----. *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1956.* [Indianapolis, Ind.], [1956].

-----. *Annual Report of the State Highway Department of the State of Indiana for the Fiscal Year Ended June 30, 1957.* [Indianapolis, Ind.], [1958].

-----. *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1959.* [Indianapolis, Ind.], [1959].

-----. *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1960.* [Indianapolis, Ind.], [1960].

-----. *The Annual Report of the State Highway Department of Indiana for the Fiscal Year Ended June 30, 1962.* [Indianapolis, Ind.], [1962].

Indiana State Teachers Association. *Readings in Indiana History.* Bloomington, Ind.: Indiana University, 1914.

"Indiana to Regulate Dimensions and Weights of Trucks." *Engineering News-Record* 106 (19 April 1931): 497.

"Indiana to Start Defense Access Roads Construction." *Engineering News-Record* 126 (3 April 1941): 505.

"Indiana to Take Over 300 Miles of County and Township Roads." *Engineering News-Record* 107 (10 September 1931): 430.

"Indiana Widens Shoulders on 1,000 Miles of Road." *Engineering News-Record* 112 (21 June 1934): 808-9.

"Indianapolis Flood Protection is Progressing." *Engineering News-Record* 95, no. 6 (6 August 1925): 213.

"Indianapolis Has Extensive Public Works Program." *Engineering News-Record* 90 (14 June 1923): 1061.

"Influence of State Highway Officials' Association." *Engineering News-Record* 79, no. 24 (13 December 1917): 1086.

"Interstate Highways to be Numbered Uniformly." *Engineering News-Record* 95 (13 August 1925): 280-281.

"An Interview: Tendencies in Bridge Construction." *Engineering News-Record* 78, no. 11 (14 June 1917): 541-43.

"Iron-Plate Arch Reduces Load of Marshland Bridge." *Engineering News-Record* 115, no. 2 (11 July 1935): 41.

Jennings, John K. "WPA Co-Operation in Road and Bridge Work." In *Proceedings of the Twenty-Fourth Annual Road School Held at Purdue University, January 24-28, 1938.* Edited by Ben H. Petty. Vol. 22, no. 4, *Engineering Bulletin Purdue University, Extension Series No. 42, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1938.

Johnson, Ted. "Precast-Concrete Control Structures: Economical for an Irrigation District." *Civil Engineering* 32, no. 7 (July 1962): 105.

Joint Highway Research Project. *A Study of Highway Needs in Indiana.* Lafayette, Ind.: Purdue University, 1958.

-----. *A Study of Highway Transportation in Indiana.* Vol. 43, no. 4, *Engineering Bulletin Purdue University, Engineering Extension Series no. 98.* Lafayette, Ind.: Purdue University, 1959.

Joy, Henry B. *The Lincoln Highway: A National Project.* New York: Lincoln Highway Association, 1916.

JRP Historical Consulting Services. "Historic Context Statement: Roadway Bridges of California: 1936 to 1959." [Davis, Calif.]: 2003.

June, Glory. *The Works Progress Administration: WPA, the Legacy of New Deal Work Programs in Indiana.* Indianapolis, Ind.: Indiana Committee for the Humanities, 1982.

Kaszynski, William. *The American Highway: The History and Culture of Roads in the United States.* Jefferson, N.C.: McFarland & Company, Inc., 2000.

Kellam, Fred. "Letters to the Editor: Age Effects Account for Molded vs. Core Concrete Strengths." *Engineering News-Record* 88 (26 January 1922): 165.

-----. "Load Capacity of Old Bridges and Methods of Making Repairs." In *Proceedings of the Nineteenth Annual Road School Held at Purdue University, January 23-27, 1933.* Edited by Ben H. Petty. Vol. 16, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 30, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1933.

Kelly, James F. "Development and Progress of Superhighways in Cook County, Illinois." In *Proceedings of the Thirty-Fifth Annual Road School Held at Purdue University, April 11-14, 1949.* Edited by Ben H. Petty. Vol. 33, no. 5, *Engineering Bulletin Purdue University, Extension Series No. 69, Engineering Extension Department.* Lafayette, Ind.: Purdue University, September 1949.

Kemp, Emory L. "National Styles in Engineering: The Case of the 19th-Century Suspension Bridge." *IA: The Journal of the Society for Industrial Archeology* 19, no. 1 (1993): 21-36.

-----. "The Introduction of Cast and Wrought Iron in Bridge Building." *IA: The Journal of the Society for Industrial Archeology* 19, no. 2 (1993): 5-16.

Ketchum, Milo S. *The Design of Highway Bridges and the Calculation of Stresses in Bridge Trusses.* New York: McGraw-Hill Book Company, 1912.

Koster, George E. *A Story of Highway Development in Nebraska.* Rev. ed. Lincoln, Neb.: Nebraska Department of Roads, 1997.

Kutz, C. W. "Ohio River Canalization: Its History and Possibilities." *Engineering News-Record* 104 (13 March 1930): 432-41.

"Lack of Engineers May Delay Indiana Work." *Engineering News-Record* 123, no. 19 (9 November 1939): 601.

Lamb, George W. "Continuous Spans Favored for Kansas Highways." *Engineering News-Record* 115 (21 November 1935): 702-6.

"Last Link in America's Dream Road." *Excavating Engineer* 50, no. 7 (July 1956): 20-68.

Lauer, John H. "Indiana's Participation in the Post-War Federal Aid Program." In *Proceedings of the Thirty-Second Annual Road School Held at Purdue University, January 21-24, 1946.* Edited by Ben H. Petty. Vol. 30, no. 4, *Engineering Bulletin Purdue University, Extension Series No. 61, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1946.

Laws of the State of Indiana (1917). Fort Wayne, Ind.: Fort Wayne Printing Company, 1917.

Laws of the State of Indiana (1919). Fort Wayne, Ind.: Fort Wayne Printing Company, 1919.

Laws of the State of Indiana (1933). Fort Wayne, Ind.: Fort Wayne Printing Company, 1933.

Laws of the State of Indiana (1953). Fort Wayne, Ind.: Fort Wayne Printing Company, 1953.

Lay, M. G. *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them.* New Brunswick, N.J.: Rutgers University Press, [1992].

Lewis, Tom. *Divided Highways: Building the Interstate Highways, Transforming American Life.* New York: Viking, 1997.

Lin, James. "The Lincoln Highway: An Introduction to America's First Transcontinental Road for the Automobile." California Institute of Technology. <http://www.ugcs.caltech.edu/~jlin/lincoln/>.

Lin, Tung Y. *Design of Prestressed Concrete Structures.* 2d ed. New York: John Wiley & Sons, 1963.

Lohr, Alan. *Early Impact of a Highway Improvement on an Urban Area.* Lafayette, Ind.: Purdue University, 1962.

Louck, Herbert. "Corrugated Metal Arch Widens Concrete Bridge." *The Highway Magazine* (June 1934): 128-30.

"Low-Cost I-Beam Bridges for Pennsylvania Highways." *Engineering News-Record* 110 (1 June 1933): 709-10.

Luten, Daniel B. "A *Double-Drum* Reinforced Concrete Arch Highway Bridge." *Engineering News* 55, no. 18 (3 May 1906): 496-97.

-----. "Letters to the Editor: A Dangerous Two-Span Arch Bridge." *Engineering News* 68, no. 25 (19 December 1912): 1156.

-----. "Reinforced Concrete Arch Bridge at Peru, Indiana." *Engineering News* 55, no. 13 (29 March 1906): 348-49.

MacDonald, Thomas H. "Highways and Railroads." *Scientific American* 146 (April 1932): 222-25.

Madison, James H. *Indiana Through Tradition and Change: A History of the Hoosier State and its People, 1920-1945.* Indianapolis, Ind.: Indiana Historical Society, 1982.

"Map of Portion of Central States, Showing Existing and Proposed Interurban Electric Railways." *Engineering News* 53, no. 14 (6 April 1905): 360.

Martin, George E. "Maintenance of Indiana Highways: Highway Bulletin No. 1." *Purdue University Engineering Departments Publications* 1, no. 1 (April 1915): 1-24.

-----. "Some Factors in the Indiana Road Problem." *Purdue University Engineering Departments Publications* (October 1916): 3-27.

"Masonry Arch Bridges of the World with Over 175-Ft. Span." *Engineering News* 62, no. 10 (2 September 1909): 254.

"Masonry for Bridges." *Stone* 14, no. 4 (March 1897).

McDaniel, Dennis K. "Water Over Water: Hoosier Canal Culverts, 1832-1847." *Indiana Magazine of History* 78, no. 4 (December 1982): 296-322.

McKibben, Frank P. "Major Provisions of an Arc-Welding Specification." *Engineering News-Record* 102 (14 March 1929): 425-27.

-----. "Welding – A New Tool for the Structural Fabricator." *Engineering News-Record* 102 (21 March 1929): 459-62.

McMinn, R. B. "Recent Developments in Precasting of Highway Bridges and Structures." *Highway Research Board Bulletin 39: Precasting Highway Bridges and Structures* (August 1951): 1-18.

"Melan Arch Bridges Over Fall Creek, Indianapolis, Ind." *Engineering News* 45, no. 15 (11 April 1901): 258.

Melan Arch Construction Company. *Designs and Specifications of Melan Bridges.* New York, n.d. Available at New York Public Library, Science and Business, New York City, NY.

Melaragno, Michele. *Preliminary Design of Bridges for Architects and Engineers.* New York: Marcel Dekker, Inc., 1998.

Melick, C. A. "Suggested Economies in Design and Construction of Bridges on Secondary Roads." In *Proceedings, Convention Group Meetings, Papers and Discussions.* Washington, D.C.: American Association of State Highway Officials, 1952.

"Merit System for Ind. Road Engineers." *Engineering News-Record* 126 (20 March 1941): 439.

Merriman, Mansfield. "The Austrian Tests of Arches." *Engineering News* 35, no. 15 (9 April 1896): 238-39.

Michael, Harold L. *Planning for County Highways.* Lafayette, Ind.: Purdue University, 1959.

Michie, Jarvis D. and Maurice E. Bronstad. *Upgrading Safety Performance in Retrofitting Traffic Railing Systems.* Washington, D.C.: Department of Transportation, Federal Highway Administration, Offices of Research and Development, September 1976.

"Mileage of Main State Highways." *Engineering News-Record* 82 (22 May 1919): 1027.

"Milestones Along the Road to Modern Highway Development." *Engineering News-Record* 118 (20 May 1937): 738.

Miller, Ann B. and Kenneth M. Clark. *A Survey of Movable Span Bridges in Virginia.* Charlottesville, Va.: Virginia Transportation Research Council, May 1998.

Mock, Elizabeth B. *The Architecture of Bridges.* New York: The Museum of Modern Art, 1949.

Moisseiff, Leon S. "Growth in Suspension Bridge Knowledge." *Engineering News-Record* 123, no. 6 (10 August 1939): 206-9.

Montgomery, Ethel L. "The Building of the Michigan Road." Thesis, Purdue University, June 1902.

Morgan, Nathan W. *Welded Bridge Construction.* Washington, D.C.: U.S. Department of Commerce, Bureau of Public Roads, [1957].

Morrison, R. L. "Letters to the Editor: Failure of a Poorly Designed Concrete Arch Bridge." *Engineering News* 68, no. 25 (19 December 1912): 1156.

"Motor-Vehicle-Tax Diversion in 1933." N.p.: n.d. Available at James Cooper's Files: General Bridge File/Concrete Design & Construction (1932-1935), Greencastle, Ind.

Moulton, Mace. "Cantilever Bridges at Kentucky and Indiana." *Transactions of the American Society of Civil Engineers* 17 (September 1887): 111-68.

Munro, John M. and George W. Wilson. *Road Transport: History and Economics Part 1. Indiana Readings in Business: Number 35.* [Bloomington, Ind.]: Indiana University, 1962.

Musleh, F. E. "The Effects of Freezing and Thawing of Prestressed Concrete." In *Proceedings of the Forty-Fifth Annual Road School Held at Purdue University, March 30 - April 2, 1959.* Edited by J. F. McLaughlin. Vol. 44, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 100, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1960.

Myers, Hallie. *Engineering Safety and Convenience into Indiana Highways.* [Indianapolis, Ind.]: Indiana State Highway Commission Available at James Cooper's Files, Hoosier Context, Greencastle, Ind. Copied from the Indiana State Highway Commission General Correspondence files found at the Indiana State Archives, Indianapolis, Ind.

National Park Service. *Lincoln Highway: Special Resource Study, Environmental Assessment.* [Washington, D.C.]: National Park Service, May 2004.

-----. *The National Road: Maryland, Pennsylvania, West Virginia, Ohio, Indiana, Illinois.* [Hollidaysburg, Penn.]: United States Department of the Interior; Southwest Pennsylvania Heritage Preservation Commission; National Park Service, July 1994.

National Research Council and Highway Research Board. *Some Economic Effects of Highway Improvement: Presented at the Thirty-Second Annual Meeting, January 13-16, 1953.* Vol. 21, Washington, D.C.: Highway Research Board, 1953.

The National Road: Maryland, Pennsylvania, West Virginia, Ohio, Indiana, Illinois. [Washington, D.C.]: United States Department of the Interior, Southwestern Pennsylvania Heritage Preservation Commission, National Park Service, July 1994.

Nebraska Department of Roads. *Second Biennial Report of the Department of Roads, 1959-1960.* Lincoln, Neb.: State of Nebraska Department of Roads, [1960].

"New Bridge Not Stone." *Indianapolis Journal.* 15 May 1902.

"New Bridge Planned." *Indianapolis Star.* 23 December 1958. Available at Indiana State Library, Indiana Clipping File: Bridges 1950-1959, Indianapolis, Ind.

"New Deal." In *Historical Dictionary of the New Deal.* Edited by James S. Olson. Westport, Conn.: Greenwood Press, 1985.

"New Highway Bill Studied by Congress." *Engineering News-Record* 124, no. 1 (4 January 1940): 25.

"A New Railway between Chicago and Cincinnati." *Engineering News* 47, no. 25 (19 January 1902): 496-99.

"New Railway in Indiana for the Pennsylvania System." *Engineering News* 76, no. 21 (15 March 1906): 1132-34.

"New Sullivan-Hutonsville Self-Anchoring Suspension Bridge Now in Use." *Indianapolis News.* 1 July 1941. Available at Indiana State Library, Indiana Clipping File: Bridges 1940-1949, Indianapolis, Ind.

"A New Welded Girder Splice." *Engineering News-Record* 103 (26 September 1929): 507-8.

"New Works Program to Get Under Way at High Speed." *Engineering News-Record* 114 (11 April 1935): 536.

"Not so Complicated." *Engineering News-Record* 123 (7 December 1939): 63.

"Obsolete Bridges on State Highways Factor in Safety." [Indianapolis, Ind.]: 1939. Available at Indiana State Library, Indiana Clipping File, Indianapolis, Ind.

"Odds and Ends." *Indianapolis News.* 6 November 1952.

"Ohio River Bridge at Evansville is Planned." *Engineering News-Record* 92, no. 24 (12 June 1924): 1032.

"Ohio River Bridge to be Toll-Free." *Engineering News-Record* 125 (16 December 1940): 855.

"The Old National Bridge: Over the White Water River at Richmond, Ind." *Proceedings of the Purdue Society of Civil Engineering* (1897): 60-62.

"Old Stone Arch has Curious Wing Walls." *Engineering News-Record* 79 (23 August 1917): 372.

"Ornamentation in Engineering Structures." *Engineering News* 62, no. 8 (19 August 1909): 202.

"Oversize Load Regulations Drawn in Indiana." *Engineering News-Record* 119 (12 August 1937): 285.

Owen, H. J. et al. "Hydraulics of River Flow Under Arch Bridges: A Progress Report." In *Proceedings of the Forty-Fifth Annual Road School Held at Purdue University, March 30 - April 2, 1959.* Edited by J. F. McLaughlin. Vol. 44, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 100, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1959.

PAC Spero & Company and Louis Berger & Associates. *Historic Highway Bridges in Maryland: 1631-1960: Historic Context Report.* Rev. ed. October 1995. Available at Maryland State Highway Administration website: <http://www.sha.state.md.us/keepingcurrent/maintainRoadsBridges/bridges/oppe/historicBridges/histbrpg0.asp>.

"Parabolic Reinforced Concrete Arch Bridge at Wabash, Ind." *Engineering News* 55, no. 11 (15 March 1906): 290.

"Parke County: Covered Bridge Capital of the World." Parke County Inc. <http://www.coveredbridges.com/>.

Parrish, C. H. "Winter Road Work for Unemployed: Indiana." *Engineering News-Record* 107 (10 December 1931): 930-931.

Parsons Brinckerhoff and Engineering and Industrial Heritage. "A Context for Common Historic Bridge Types, NCHRP Project 25-25, Task 15." National Cooperative Highway Research Program, Transportation Research Board, 2005.

Parsons Brinkerhoff Quade & Douglas, Inc. *Small Structures on Maryland's Roadways: Historic Context Report.* Baltimore, Md.: Maryland State Highway Administration, Maryland Department of Transportation, June 1997.

Patton, Phil. *Open Road: A Celebration of the American Highway.* New York: Simon and Schuster, 1986.

"Personal Notes: Frank Y. Hardy." *Engineering News-Record* 95, no. 10 (3 September 1925): 401.

Petty, Ben H. "County Bridges and Culverts – A Major Problem." In *Proceedings of the Twenty-Seventh Annual Road School Held at Purdue University, January 20-24, 1941.* Vol. 25, no. 3, *Engineering Bulletin Purdue University, Extension Series No. 50, Engineering Extension Department.* Lafayette, Ind.: Purdue University, May 1941.

-----. "Highway Demand is Turning from Main to Local Roads." *Engineering News-Record* 110 (5 January 1933): 7-10.

-----. "Highway Development as it Affects the Farmer." *Indiana Highways and Motors* 2, no. 3 (April 1924): 22-23.

-----. "Road Administration Revamped in Indiana." *Engineering News-Record* 109 (29 September 1932): 384-85.

-----. "Township Roads Should be Merged with County Roads." *Engineering News-Record* 98, no. 1 (6 January 1927): 22-24.

Pfeiffer, David A. "Ike's Interstate at 50: Anniversary of the Highway System Recalls Eisenhower's Role as Catalyst." *Prologue* 38, no. 2 (summer 2006). Available at National Archives website: <http://www.archives.gov/publications/prologue/2006/summer/interstates.html>.

Phillips, Clifton J. *Indiana in Transition: The Emergence of an Industrial Commonwealth, 1880-1920.* Indianapolis, Ind.: Indiana Historical Bureau & Indiana Historical Society, 1968.

Piper, Clyde. "Care of Bridge Floors." In *Proceedings of the Eleventh Annual Road School Held at Purdue University, January 19 to 23, 1925.* Edited by Ben H. Petty. Vol. 9, no. 10, *Engineering Bulletin Purdue University, Bulletin No. 10, Engineering Extension Service.* Lafayette, Ind.: Purdue University, March 1925.

Plowden, David. *Bridges: The Spans of North America.* New York: Viking Press, 1974.

Plummer, Fred L. "Welded Rigid Frames, European Style." *Engineering News-Record* 125 (18 July 1940): 55-57.

Podolny, Walter and John B. Scalzi. *Construction and Design of Cable-Stayed Bridges.* New York: J. Wiley & Sons, 1986.

Portland Cement Association. *Precast Concrete Bridge Decks.* Chicago: Portland Cement Association, 1953.

Post-Tensioning Institute. *Post-Tensioning Manual.* 2d ed. Glenview, Ill.: Post-Tensioning Institute, 1976.

Potter, A. A. "Education in Fundamentals Finds Wide Support: Educate Men With Capacity to Become Engineers." *Engineering News-Record* 108 (14 January 1932): 63-64.

-----. "Personnel System for a College of Engineering." *Engineering News-Record* 93, no. 9 (28 August 1924): 330-331.

Prather, Geneal A. "The Building of the Michigan Road." M.A. Thesis, Indiana University, 1941.

"Prequalifications Set Up in Indiana." *Engineering News-Record* 119 (5 August 1937): 205.

Preston, Howard L. *Dirt Roads to Dixie.* Knoxville: University of Tennessee Press, 1991.

"Pre-Stressed 108-Ft. Girders in German Bridge." *Engineering News-Record* 124 (28 March 1940): 60.

Priest, H. M. "Strength of Structural Welds." *Engineering News-Record* 107 (17 September 1931): 436-40.

"Provisions of Welding Society Code for Structural Welding." *Engineering News-Record* 103 (18 July 1929): 92-93.

Pruett, W. G. "Post-War Highway Planning." *Excavating Engineer* 37, no. 10 (October 1943): 484-518.

"Public Roads." Federal Highway Administration. <http://www.tfhrc.gov/pubrds/summer96/p96su10.htm>.

"Public-Works Administration Allotments and Approvals to Oct. 1, 1933." *Engineering News-Record* 111 (5 October 1933): 415.

"Purdue to Celebrate Semi-Centennial." *Engineering News-Record* 92 (24 April 1924): 725.

"Purdue to Offer Curriculum in *Public Service Engineering*." *Engineering News-Record* 114 (14 February 1935): 266.

"Quintuple Arch Bridge for Indiana County." *The Highway Magazine* (January 1940): 8-9.

Quivik, Fredric L. and Dale L. Martin. "Iron & Steel Bridges in Minnesota." National Register of Historic Places, National Park Service, 1989. Available at Indiana Department of Natural Resources, Division of Historic Preservation and Archaeology.

Rader, A. J. "Repairing Old Bridges." In *Proceedings of the Twenty-Fifth Annual Road School Held at Purdue University, January 23-27, 1939.* Edited by Ben H. Petty. Vol. 23, no. 4, *Engineering Bulletin Purdue University, Extension Series No. 44, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1939.

"Railroad Utilizes Old Steel Spans in Road Bridges." *Engineering News-Record* 81, no. 7 (15 August 1918): 320-321.

"Reinforced Concrete Arch Bridge at Yorktown, Ind." *Engineering News* 53, no. 19 (11 May 1905): 477-78.

"A Reinforced-Concrete Arch Highway Bridge in Indiana Wrecked by Erosion of Foundations." *Engineering News* 63, no. 11 (17 March 1910): 323-24.

"Replace 5,228 Bridges in State, Repair 4,412, Two Experts Say." *Indianapolis Star.* 26 October 1979.

Reppert, Charles M. "Aluminum Enters Bridge Construction." *Engineering News-Record* 111 (23 November 1933): 611-15.

Report of the Indiana Highway Commission (1914). [Indianapolis, Ind.], 1914.

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1928.* Indianapolis, Ind.: William B. Burford, 1929.

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1929.* Indianapolis, Ind.: William B. Burford, 1930.

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1930.* Indianapolis, Ind.: William B. Burford, 1930.

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1931.* Indianapolis, Ind.: William B. Burford, 1932.

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1932.* Indianapolis, Ind.: William B. Burford, 1933.

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1933.* Indianapolis, Ind.: William B. Burford, 1934.

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1934.* Indianapolis, Ind.: William B. Burford, [1935].

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1937.* Indianapolis, Ind.: William B. Burford, [1938].

"Report of the Indiana State Highway Commission." In *Year Book of the State of Indiana for the Year 1938.* Indianapolis, Ind.: William B. Burford, [1939].

"Report of the Research and Extension Activities of the Engineering Schools and Departments for the Sessions of 1935-1936." *Engineering Bulletin Purdue University, Research Series Number 55, Engineering Experiment Station* 20, no. 5 (September 1936): 5-21.

"Report of the Research and Extension Activities of the Engineering Schools and Departments for the Sessions of 1936-1937." *Engineering Bulletin Purdue University, Research Series Number 57, Engineering Experiment Station* 21, no. 4 (July 1937): 3-44.

"Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1917.* [Indianapolis, Ind.]: 1918.

"Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1918.* Indianapolis, Ind.: William B. Burford, 1919.

"Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1919.* Fort Wayne, Ind.: Fort Wayne Printing Company, 1920.

"Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1920.* Fort Wayne, Ind.: Fort Wayne Printing Company, 1921.

"Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1921.* Indianapolis, Ind.: William B. Burford, 1922.

"Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1922.* Indianapolis, Ind.: William B. Burford, 1923.

"Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1927.* Indianapolis, Ind.: William B. Burford, 1928.

Riddell, Campbell J. "The Aesthetic Qualities of Bridges." *The Institution of Municipal Engineers* 92, no. 1 (January 1965): 28-29.

Roadruck, J. W. "Some Examples of Road and Bridge Building Economy." In *Proceedings of the Nineteenth Annual Road School Held at Purdue University, January 23-27, 1933.* Edited by Ben H. Petty. Vol. 16, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 30, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1933.

Root, W. H. "Let's Keep What We Have Until We Get More To Keep." In *Proceedings of the Twenty-Ninth Annual Road School Held at Purdue University, January 25-27, 1943.* Edited by Ben H. Petty. Vol. 27, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 55, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1943.

Rose, Mark. *Interstate: Express Highway Politics 1939-1989.* Rev. ed. Knoxville, Tenn.: University of Tennessee Press, 1990.

Ruminer, C. R. "Unreinforced Concrete Arches." *Roads and Streets* 85, no. 12 (December 1942): 27-28.

"The Saguenay is Bridged with Aluminum." *Engineering News-Record* 144 (12 January 1950): 32-35.

"Salary Increase for Indiana Road Engineers." *Engineering News-Record* 126 (20 February 1941): 297.

"Sale of Kentucky Bond Assures Toll Bridge Construction." *Engineering News-Record* 102 (16 May 1929): 805.

"Scary Bridge Rehabbed for Economic Boon." *Civil Engineering* 66, no. 3 (March 1996): 12-14.

Seely, Bruce E. *Building the American Highway System: Engineers as Policy Makers.* Philadelphia, Penn.: Temple University Press, 1987.

"Seventh Annual Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1925.* Indianapolis, Ind.: William B. Burford, 1925.

Sharp, Leslie N. "What is the Dixie Highway?" In *Drivin' the Dixie: Automobile Tourism in the South, SCA Conference, October 21-24, 1998.* Chattanooga, Tenn.: SCA, 1996.

Shepard, Joseph K. "A Bridge To Safety." *Indianapolis Star Magazine,* 13 June 1965.

Shurig, D. G. "Minor Maintenance of County Bridges." In *Highway Extension and Research Project for Indiana Counties. Engineering Bulletin Purdue University, County Highway Series No. 7.* Lafayette, Ind.: Purdue University, August 1964.

Simmons, David A. "*The Continuous Clatter*: Practical Field Riveting." In *Repairing and Restoring Historic Bridges: Keeping Faith with their Makers, a Workshop on 4 June 1998.* [Indianapolis, Ind.]: [1998].

"Sixth Annual Report of the State Highway Commission." In *Year Book of the State of Indiana for the Year 1924.* Indianapolis, Ind.: William B. Burford, 1925.

Slack, Searcy B. "Bridge Curbs and Rails." *Engineering News-Record* 121 (20 October 1938): 498-500.

Smith, Albert. "Relation of Bridge Specifications to Highway Improvement." *Engineering Record* (21 January 1911): 83.

Smith, Earl R. "Repairing Old Bridges." In *Proceedings of the Twenty-Fifth Annual Road School Held at Purdue University, January 23-27, 1939.* Edited by Ben H. Petty. Vol. 23, no. 4, *Engineering Bulletin Purdue University, Extension Series No. 44, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1939.

Smythe, J. V. "Progress in Railway Grade Separation and Protection Work in Indiana." In *Proceedings of the Twenty-Third Annual Road School Held at Purdue University, January 25-29, 1937.* Edited by Ben H. Petty. Vol. 21, no. 3, *Engineering Bulletin Purdue University, Extension Series No. 39, Engineering Extension Department.* Lafayette, Ind.: Purdue University, May 1937.

Some Correspondence of the Indiana State Highway Commission. [Indianapolis, Ind.]: The Indiana Association of County Surveyors and County Engineers, 1925.

"Some Current Highway and Highway Bridge Activities." *Engineering News-Record* 105 (25 October 1930): 502-4.

Sozen, M. A. and C. P. Siess. "Investigation of Prestressed Reinforced Concrete for Highway Bridges." *Highway Research Record*, no. 400 (1972): 29-30.

Stager, Claudette. "Introduction." In *Looking Beyond the Highway: Dixie Roads and Culture.* Edited by Claudette Stager and Martha Carver. Knoxville, Tenn.: University of Tennessee Press, 2006.

"The State Administration of Public Highways in the United States." *Engineering News* 67, no. 13 (28 March 1912): 595-98.

"State Auctions Old Stone Bridges." *Engineering News-Record* 89 (7 December 1922): 986.

"State Engineers for Public Works Announced by Secretary Ickes." *Engineering News-Record* 111 (17 August 1933): 208-10.

"State Highway Commission of Indiana." In *Year Book of the State of Indiana for the Year 1946.* Indianapolis, Ind.: [1947].

"State Highway Commission of Indiana." In *Year Book of the State of Indiana for the Year 1947.* Indianapolis, Ind.: [1948].

"State Highway Commission of Indiana." In *Year Book of the State of Indiana for the Year 1948.* Indianapolis, Ind.: [1949].

"State Highway Commission of Indiana." In *Year Book of the State of Indiana for the Year 1949.* Indianapolis, Ind.: [1950].

"State Highway Commission of Indiana." In *Year Book of the State of Indiana for the Year 1950.* Indianapolis, Ind.: [1951].

State Highway Commission of Indiana. *Highways of Indiana: A Report on the State Highway System of Indiana Based on a Comprehensive Field Inventory, Traffic Survey, Subsequent Studies and Analyses.* [Indianapolis, Ind.]: State Highway Commission of Indiana, 1948.

-----. *Indiana Traffic Survey, 1932-1933.* [Indianapolis, Ind.]: State Highway Commission of Indiana, [1933].

-----. *Report of a Survey of Vehicular Traffic on the State and County Highways of Indiana, 1932-1933.* [Indianapolis, Ind.], [1933].

-----. *Standard Specifications for Bridge Construction.* [Indianapolis, Ind.]: State Highway Commission of Indiana, September 1936.

-----. *Standard Specifications for Bridge Construction.* [Indianapolis, Ind.]: State Highway Commission of Indiana, November 1939.

-----. *Standard Specifications for Road and Bridge Construction and Maintenance.* [Indianapolis, Ind.]: [State Highway Commission of Indiana], 1946.

"State Highway Departments Spent $650,000,000 in 1925." *Engineering News-Record* 97, no. 20 (11 November 1926): 794.

"State Statistician's Statement." *Bulletin of the Indiana Highway Commission* (1914). Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

"State's County Bridges and Culverts Major Problem for Road Officials." *Indianapolis Star.* 30 November 1941. Available at Indiana State Library, Indiana Clipping File: Bridges 1940-1949, Indianapolis, Ind.

"States to Build 26,841 Miles of Roads in 1927." *Engineering News-Record* 98, no. 14 (7 April 1927): 589.

State-Wide Highway Planning Survey [Indiana]. *The Present Status of the State Highway System and a Suggested Priority of Improvement to Reasonable Standards: A Special Report of the State-Wide Highway Planning Survey in Cooperation with U.S. Public Roads Administration.* [Indianapolis, Ind.]: State Highway Commission of Indiana, December 1940.

Statistical Report for the State of Indiana. Fort Wayne, Ind.: Fort Wayne Printing Co., 1930-1951.

Steinman, D. B. *The Wichert Truss.* New York: D. Van Nostrand Company, Inc., 1932.

Steinwedel, Albert. "Indiana Gasoline Tax Rebate - Income and Allocation." In *Proceedings of the Forty-Fifth Annual Road School Held at Purdue University, March 30 - April 2, 1959.* Edited by J. F. McLaughlin. Vol. 44, no. 2, *Engineering Bulletin Purdue University, Extension Series No. 100, Engineering Extension Department.* Lafayette, Ind.: Purdue University, March 1960.

Stemler, J. R., J. W. Clark, and G. O. Hoglund. "Welded Aluminum Highway Structures." *Highway Research Board Bulletin 361: Aluminum Highway Culverts and Bridges* (1962): 1-3.

"A Stone Arch Bridge of Moderate Cost." *Engineering News* 41 (30 March 1899): 197-98.

"Stone Bridge Contract." *Indianapolis Journal.* 7 May 1902.

Stoner, John E. *Guidelines for Highway Policy.* [Bloomington, Ind.]: Indiana University, 1964.

-----. "Improving County Highway Administration." *Better Roads* 26, no. 11 (November 1956): 40-42.

Storrow Kinsella Associates. "Indianapolis Park and Boulevard System." National Register of Historic Places, National Park Service, 2004. Available at Indiana Department of Natural Resources, Division of Historic Preservation and Archaeology.

Strobel, G. C. and John Heald. "Theoretical and Practical Discussion of the Design, Testing and Use of Pretensioned Prestressed Concrete Piling." *Journal of the Prestressed Concrete Institute* 6, no. 3 (September 1961): 22-23.

"Ten Years of Achievement with Rigid-Frame Bridges." *Engineering News-Record* (27 April 1933): 531-33.

"Texas Historic Bridge Inventory: Survey of Non-Truss Structures." N.p.: n.d. Available at Environmental Affairs Division, Texas Department of Transportation, Austin, Tex.

Thornbrough, Emma L. *Indiana in the Civil War Era, 1850-1880.* Indianapolis, Ind.: Indiana Historical Society, 1989.

"Three-Cent Gas Tax Bill Passes Indiana Senate." *Engineering News-Record* 94 (26 February 1925): 369.

"Three New Interstate Bridges Ready to be Put into Service." *Engineering News-Record* 108 (30 June 1932). Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

Titus, William J. "An Attractive Concrete Bridge in Indiana." *The American City Magazine* 34, no. 5 (May 1926): 519-20.

-----. "Concrete Girders Jacked Up to Replace Settled Bridge Pier." *Engineering News-Record* 87, no. 16 (20 October 1921): 638.

-----. "Construction and Maintenance of Small Bridges and Culverts." In *Proceedings of the Tenth Annual Road School Held at Purdue University, January 7 to 11, 1924.* Edited by Ben H. Petty. Vol. 8, no. 2, *Engineering Bulletin Purdue University, Bulletin No. 50, Engineering Extension Service.* Lafayette, Ind.: Purdue University, March 1924.

-----. "Indiana State Highway Commission Correspondence on Roads." Indianapolis, Ind.: 1920-1929. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

-----. "Some Highway Bridge Problems in Indiana." *Indiana Highways and Motors* 1, no. 4 (November 1923): 9-13.

-----. "Tightening Tension Bars of a Bridge by Heating and Upsetting." *Engineering News-Record* 90, no. 12 (22 March 1923). Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

"Township Roads in Indiana Pass to County Control." *Engineering News-Record* 109 (1 September 1932): 287.

"Transportation." *Engineering News-Record* 144 (23 March 1950): 108-15.

"Trend of Highway Development - A Survey." *Engineering News-Record* 85, no. 27 (30 December 1920): 1271-72.

Troitsky, M. S. *Orthotropic Bridges Theory and Design.* Cleveland, Ohio: James F. Lincoln Arc Welding Foundation, 1967.

Tyrrell, Henry G. *Bridge Engineering.* Evanston, Ill., 1911.

United States Department of Agriculture and Office of Public Roads. "Public Roads of Indiana: Mileage and Expenditures in 1904." In *Office of Public Roads Circular No. 66. Office of Public Roads Circular No. 66.* Washington, D.C.: GPO, February 1907.

United States Federal Works Agency. *Final Report on the WPA Program, 1935-43.* Washington, D.C.: GPO, 1947.

Upham, Charles M. "The Post-War Highway Program." In *Proceedings of the Thirty-Second Annual Road School Held at Purdue University, January 21-24, 1946.* Edited by Ben H. Petty. Vol. 30, no. 4, *Engineering Bulletin Purdue University, Extension Series No. 61, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1946.

"Urgent Defense Road Needs Put at $287,000,000." *Engineering News-Record* 126 (20 February 1941): 1, 12.

"Value of Different Kinds of Stone Produced in 1894 and 1895." *Stone* 14, no. 3 (February 1897).

Viest, I. M., R. S. Fountain, and C. P. Siess. "Development of the New AASHO Specifications for Composite Steel and Concrete Bridges." *Highway Research Board Bulletin 174: Studies in Composite Design of Steel Beam and Concrete Bridge Decks* (1958): 1-16.

"Wanted – A Connected National Highway System." *Engineering News-Record* 81, no. 14 (3 October 1918): 608.

Weingroff, Richard F. "Federal-Aid Highway Act of 1956: Creating the Interstate System." Federal Highway Administration. <http://www.fhwa.dot.gov/infrastructure/rw96e.htm>.

-----. "For the Common Good: The 85th Anniversary of a Historic Partnership." *Public Roads* 64, no. 5 (March/April 2001): 30-45. Available at Turner-Fairbank Highway Research Center website: http://www.tfhrc.gov/pubrds/marapr01/commongood.htm.

Weintraut, Linda. *Resource Protection Planning Process: The Development of Transportation in Nine Counties of Northwestern Indiana, 1670-1890.* Indianapolis, Ind.: Department of History, Indiana University-Purdue University Indianapolis, 1991.

-----. *Resource Protection Planning Process: The Development of Transportation in Nine Counties of Northwestern Indiana, 1890-1940.* Indianapolis, Ind.: Department of History, Indiana University-Purdue University Indianapolis, 1991.

Wendrich, Lawrence H. "The State Highway Commission of Indiana a Study of Organization and Functions." Bloomington, Ind.: Indiana University, Department of Government, The Institute of Politics, 1942. Available at James Cooper's Files, Hoosier Context, Greencastle, Ind.

Wengenroth, Reece H. and Howard A. Mix. "Fifty-Year History of Movable Bridge Construction - Part III." *Journal of the Construction Division, American Society of Civil Engineers* 101, no. C03 (September 1975): 545-57.

"What Public Works?" *Engineering News-Record* 110 (4 May 1933): 567.

Wheeler, John W. "Progressive Road Widening Planned for Indiana." *Engineering News-Record* 115 (5 December 1935): 773.

Wheeler, Porter K. *Highway Assistance Programs: A Historical Perspective.* Reprint ed. [Washington, D.C.]: Congress of the United States, Congressional Budget Office, June 1978.

"Where We Stand on Roads for Defense." *Engineering News-Record* 125 (24 October 1940): 77-78.

"White River Bridge Bond Issue Effort Pledged by County." *The Indianapolis Times.* 20 January 1958.

Whitney, Charles S. "Early Rigid-Frame Bridge." *Engineering News-Record* 111 (20 July 1933): 85.

Wildhack, Bill. "Don't Quote Me." *Indianapolis News.* 18 December 1962.

Winslow, Gil C. "Cleaning and Straightening Waterways at Bridges and Culverts (Hancock County, Indiana)." In *Proceedings of the Twenty-Fifth Annual Road School Held at Purdue University, January 23-27, 1939.* Edited by Ben H. Petty. Vol. 23, no. 4, *Engineering Bulletin Purdue University, Extension Series No. 44, Engineering Extension Department.* Lafayette, Ind.: Purdue University, July 1939.

Wisconsin Department of Transportation. *Historic Highway Bridges in Wisconsin: Volume 2, Part 1, Truss Bridges.* [Madison, Wis.]: Wisconsin Department of Transportation, 1998.

Woods, Kenneth B. "Aims and Activities of the Joint Highway Research Project: A Progress Report of an Investigation Conducted by the Engineering Experiment Station of Purdue University." *Engineering Bulletin Purdue University, Research Series Number 71, Engineering Experiment Station* (March 1940): 1-84.

Wooton, Paul. "ENR News of the Week: Washington Highlights." *Engineering News-Record* 118 (10 June 1937): 857.

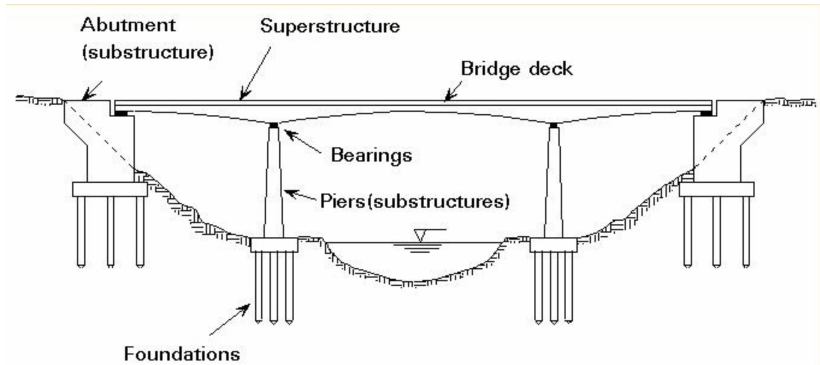
-----. "Washington Highlights." *Engineering News-Record* 122 (5 January 1939): 4.

"World's Longest Girder Lift Span." *Engineering News-Record* 144 (16 February 1950): 42-43.

Appendix A. Glossary of Basic Bridge Types and Terms

Glossary of Basic Bridge Types and Terms

Abutment – A substructure supporting the ends of a single span or the extreme ends of a multi-span superstructure and, in general, retaining or supporting the approach embankment.



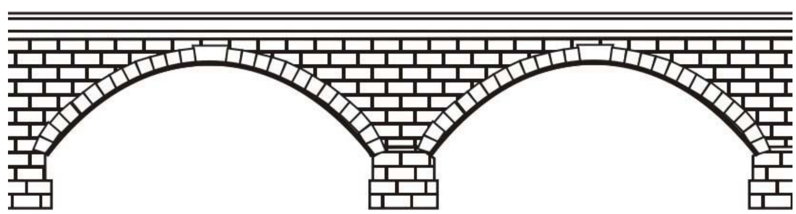
Bridge elements

Anchor span – The span that counterbalances and holds in equilibrium the fully cantilevered portion of an adjacent span.

Approach span – A term to designate the spans located on either side of the main span; see main span.

Arc-welding – Arc-welding is a process by which steel parts are joined in their molten state, thus creating a metallurgical bond. Intense heat is provided to the joint by an electric arc. See welding.

Arch – The arch bridge, whose basic technology dates back to ancient Rome, is a semi-circular form that can be composed of masonry, brick, steel, timber, or concrete. The structure converts the downward force of its own weight, and of any weight pressing down on top of it, into an outward force along its sides and base. Variations include deck arch and through arch.


Stone arch

Arch rib or ring – The main support element used in open spandrel arch construction; it spans a waterway or roadway and supports the deck.

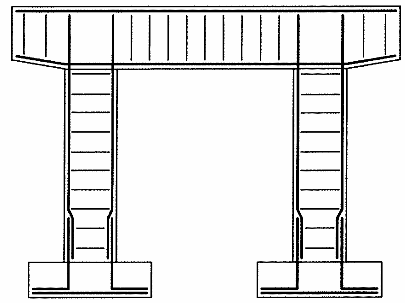
Bascule bridge – A moveable bridge type, constructed mostly from 1900 through the 1930s that has one or two leaves that open on a hinge to raise the leaf vertically. Various types include Milwaukee, Chicago, Strauss, and Scherzer.

Beam – A linear structural member designed to span from one support to another. A rigid and horizontal structural element. The earliest beam bridges consisted of wooden planks set on timber or masonry abutments. As material technology advanced, the favored materials for beam bridges became steel and concrete.

Bearing – Mechanical device that transfers the load from the superstructure to the substructure.

Bent – Bents are substructure units made up of two or more columns connected at their tops by a cap or other member holding them in place.

Primary Reinforcing



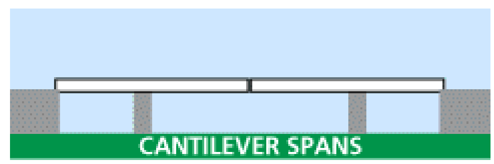
Column Bent

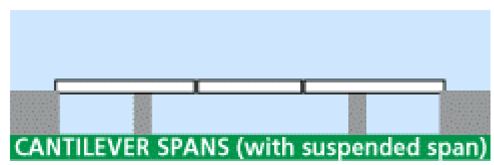
Bolt connections – A connection system of bolts and nuts, used on trusses, and steel beams and girders.

Box culvert – A box culvert is cast-in-place or pre-cast reinforced concrete and has a square or rectangular shape; it is typically located under the embankment to drain water from one side of the road to the other.

Bridge – A structure, including superstructure, deck and supports, erected over a depression or an obstruction such as water, highway, or a railway and having a track or road for carrying traffic or other moving loads. INDOT and NBI define a bridge as a structure with a length of more than 20 feet (6.1 meters) between abutments or extreme ends of openings for multiple box culverts.

Cantilever – A span that projects beyond a supporting column or wall and is counterbalanced and/or supported at only one end. Cantilever designs were introduced in the United States in the late 1870s. Although first applied to truss construction, cantilever and continuous support methods were later applied to other bridge types, including concrete girders and steel I-beams. Cantilevered designs were advantageous because of their adaptability to long spans. The cantilever bridge could be erected without falsework and without obstructing the channel. Its length was mainly limited to between 500 and 1,000 feet.





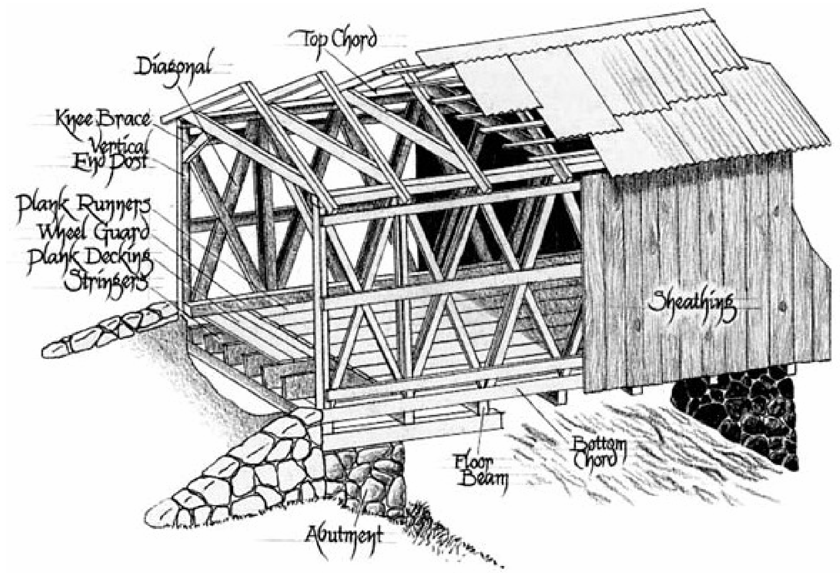
Compression – A type of stress involving pressing together. It tends to shorten a member (the opposite of tension).

Concrete – Concrete is a building material made of sand and gravel bonded together with Portland cement into a hard, compact substance. Types include unreinforced, reinforced, and prestressed.

Continuous support system – The superstructure spans uninterrupted over one or more intermediate supports. Continuous designs were introduced in the United States in the late 1870s. Although first applied to truss construction, continuous and cantilever support methods were later applied to other bridge types, including concrete girders and steel I-beams. Continuous designs, while statically indeterminate, were advantageous because they required less steel and concrete, produced less deflection, and avoided problematic joints over piers. Railroad engineers were among the first to design continuous structures, especially for overpasses that elevated roadways over railways.

Because less steel and concrete were required for beams, continuous structures feature greater vertical clearance and less girth than non-continuous spans.

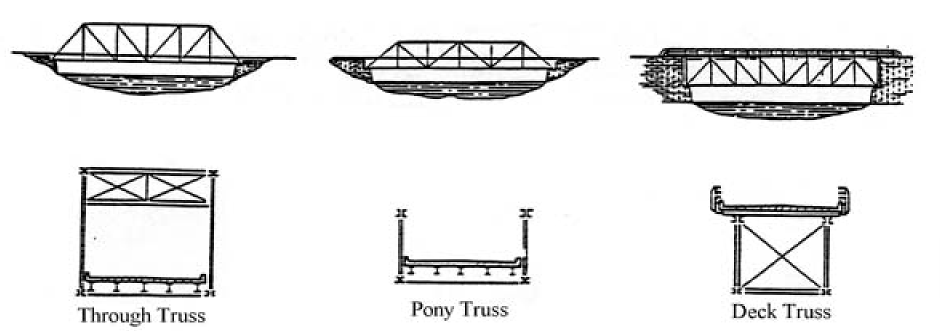
Covered bridge – An overhead truss system, primarily of timber, clad with wood sheathing and a roof to protect the wood superstructure/truss from the elements.



Covered bridge

Culvert – A short span that carries a road over a small waterway or trail with the structure entirely below the elevation of the road. INDOT defines it as a structure not classified as a bridge, which provides an opening under the roadway. Spans of less than 20 feet are not classified in NBI. Culverts have two basic forms – box and pipe. They may have single or multiple spans, also called units or cells, and often feature a floor. Culverts may be constructed in the following materials: steel, corrugated metal, concrete, timber or masonry. Timber was not a durable material for culvert construction. Masonry was superseded by concrete in the early twentieth century, but was used for later culverts in cases where stone was readily available and aesthetics were a concern. For example, masonry culverts were built by federal relief program laborers during the Depression.

Deck – The roadway surface of a bridge. In a deck-type bridge, the structural system lies beneath the deck (roadway).



Truss configurations

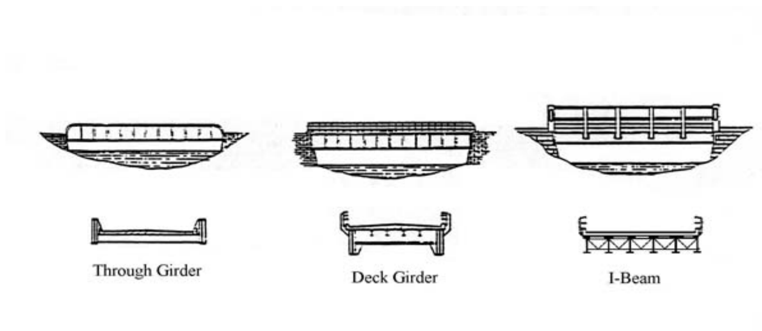
Deck arch – In a deck arch, the roadway is located above the arch ring and can feature either closed or open spandrels.

Deck truss – A truss that carries its deck on its top chord. See also through truss and pony truss.

Diaphragm – A member placed within a member or superstructure system to facilitate construction, distribute stresses, and improve strength and rigidity.

Grade separation – A crossing of two highways, or a highway and a railroad, at different levels. The bridge that spans highways or railroad tracks (as in an overpass) is a grade separation structure.

Girder – A horizontal structural member supporting vertical loads by resisting bending. The girder bridge is composed of a series of steel or concrete beams placed parallel to traffic, resting on abutments placed on either end of the bridge. The deck is set atop the girders. The use of intermediate piers allows an almost unlimited total bridge length. Girder bridges became a prevalent bridge type in the United States in the twentieth century. They typically span between 100 and 320 feet, but can reach a length of 1,000 feet. The maximum length of a span is determined by the strength of the material and the depth of the girder. A plate girder is composed of built-up and connected steel plates with a deep web and top and bottom flanges.



Girder configurations

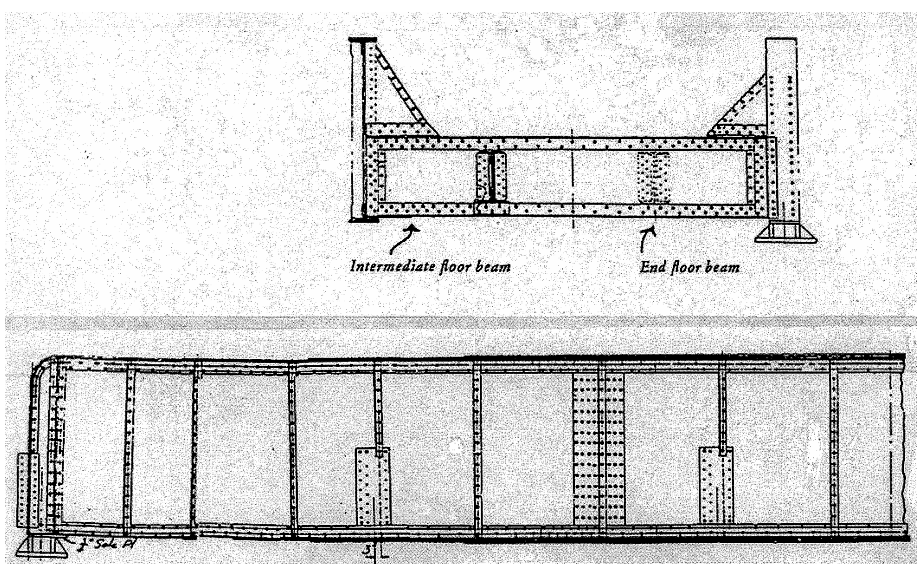


Plate girder

MEAD & HUNT

Lateral bracing – Members used to stabilize a structure by introducing diagonal connections.

Lift bridge – A moveable bridge type where the moveable span maintains a constant horizontal position while it rises and descends vertically. The moveable section is situated between two towers that use a system of pulleys to raise and lower the bridge. The vertical lift bridge type was designed to replace the swing bridge and be less obstructive of the waterway.

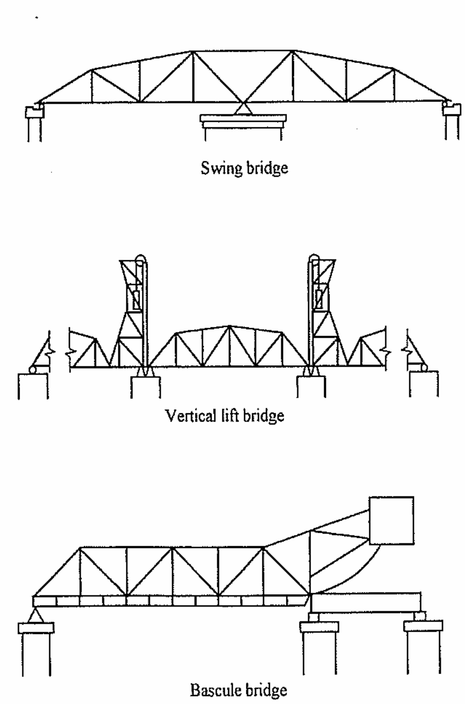
Load – Weight distribution through a structure.

Low truss – A truss that carries its traffic near its top chord but not low enough to allow cross bracing between the parallel top chords. The roadway is located between the load-carrying members. This arrangement is also called a pony truss.

Main span – Longest span in the structure (can be simple or continuous support system).

Members – One of many parts of a structure, especially one of the parts that is assembled to form a truss.

Moveable bridge – A structure with a deck that can be moved to clear a navigation channel. Depending on its height over the water, a moveable bridge may allow small craft to pass under it while it continues to carry vehicles over the waterway. When larger vessels approach, the bridge simply moves out of the way and then returns to its position after the vessel has passed. Three primary types of moveable bridges are swing, lift, and bascule.



(Source: Ann B. Miller and Kenneth M. Clark, A Survey of Movable Span Bridges in Virginia. Charlottesville, VA.: Virginia Transportation Research Council, July 1996).

Moveable bridges

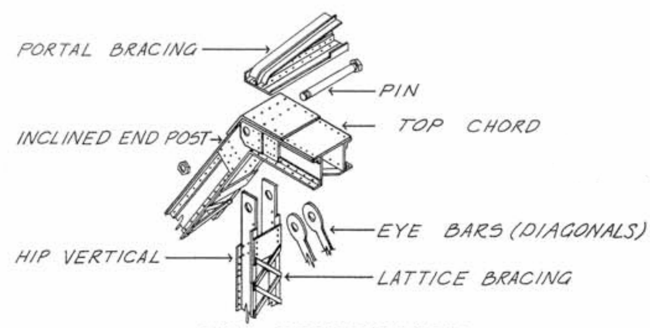
Overhead truss – In an overhead truss the roadway is located under and between the load-carrying members with traffic traveling through the truss. An overhead truss features lateral-bracing between the top chords over the deck. Also referred to as a through truss.

Overpass – A grade separation where the highway passes over a highway or railroad.

Pier – Solid, one-piece superstructure support of stone, concrete, or timber that rests on one large footing.

Pile – A column of wood, steel, or concrete that is driven into the ground to provide support for a structure.

Pinned connections – A connection type where a cylindrical bar is used to connect various members of a truss; such as those inserted through the holes of a meeting pair of eyebars. Introduced in the 1840s, pin connections are the earliest connection type and were commonly used for trusses built before 1910s. Pin connections allowed for easier erection of bridges, much of which could be completed offsite. Pin connections remained popular until the end of the nineteenth century when they were replaced by riveted connections.



PIN CONNECTION

Pipe culvert – A structure not classified as a bridge, which provides an opening by means of a pipe under the roadway.

Pony truss – A truss that carries its traffic near its top chord but not low enough to allow cross bracing between the parallel top chords. The roadway is located between the load-carrying members. This arrangement is also called a low truss. See also deck and through truss.

Post-tensioned concrete – The compressing of the concrete in a structural member by means of tensioning high-strength steel tendons against it after the concrete has cured.

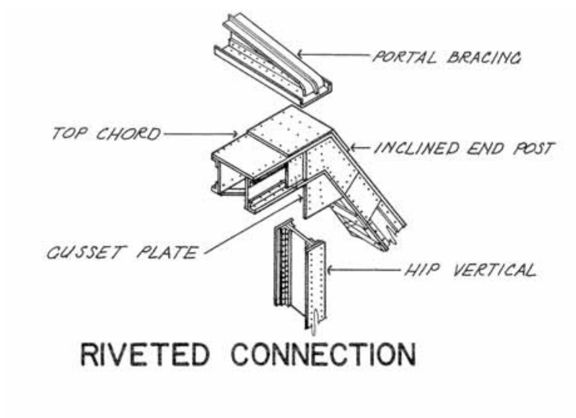
Prestressed concrete – A concrete structural member that has had an initial compressive stress applied either by pretensioning or post-tensioning. Prestressed concrete was employed beginning in the 1950s.

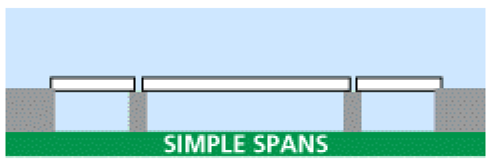
Pretensioned concrete – The compressing of the concrete in a structural member by pouring the concrete for the member around stretched high-strength steel strands, curing the concrete, and releasing the external tensioning force on the strands.

Reinforced concrete – The placement of metal wire or rebar in structural member forms before pouring concrete to provide additional strength.

Rigid frame bridge – A type of bridge in which the superstructure and substructure act as a single unit and were built as a continuous form. Concrete rigid frames were commonly used across the nation for highway and freeway bridge construction. The bridge type generally spans up to 100 feet and has an arched profile.

Riveted connections – A connection type using a metal shank with a large head on one end that forms its connection by passing the shank through aligned holes in the plates and hammering the second end to form a similar shape. Riveting is a common connection type for trusses and beam/girders.

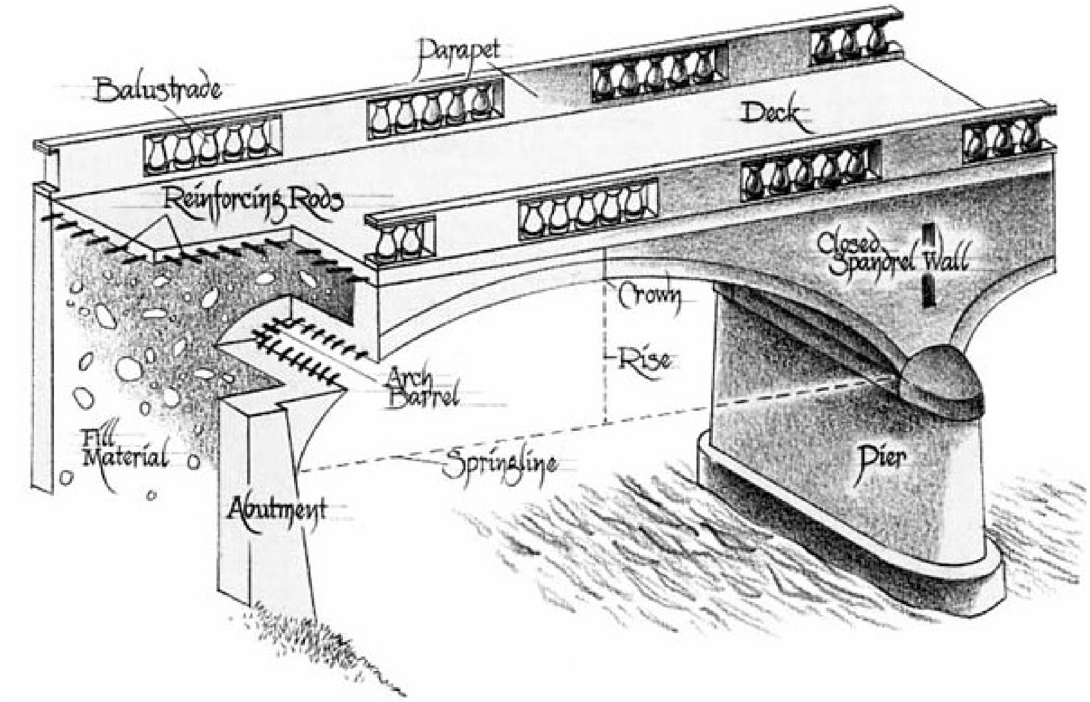




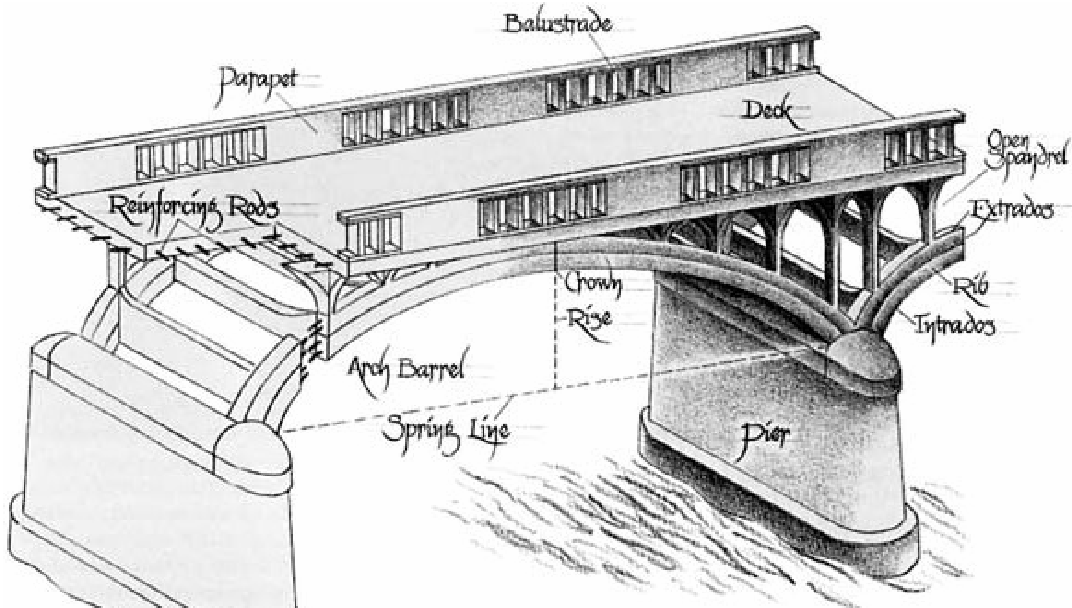
Simple span – Superstructure is completely supported between two supports.

Span – The distance between two supports (either abutments or piers) of a structure; also refers to the superstructure itself.

Spandrel – The space between the arch ring and the deck on an arch bridge is the spandrel. The spandrel may be walled and filled, known as a closed spandrel, or it may be open, known as open spandrel.



Closed spandrel bridge



Open spandrel bridge

Specifications – The standard specifications, supplemental specifications, special provisions, and written or printed agreements and instructions pertaining to the method and manner of performing the work or to the quantities and qualities of the materials to be furnished under contract.

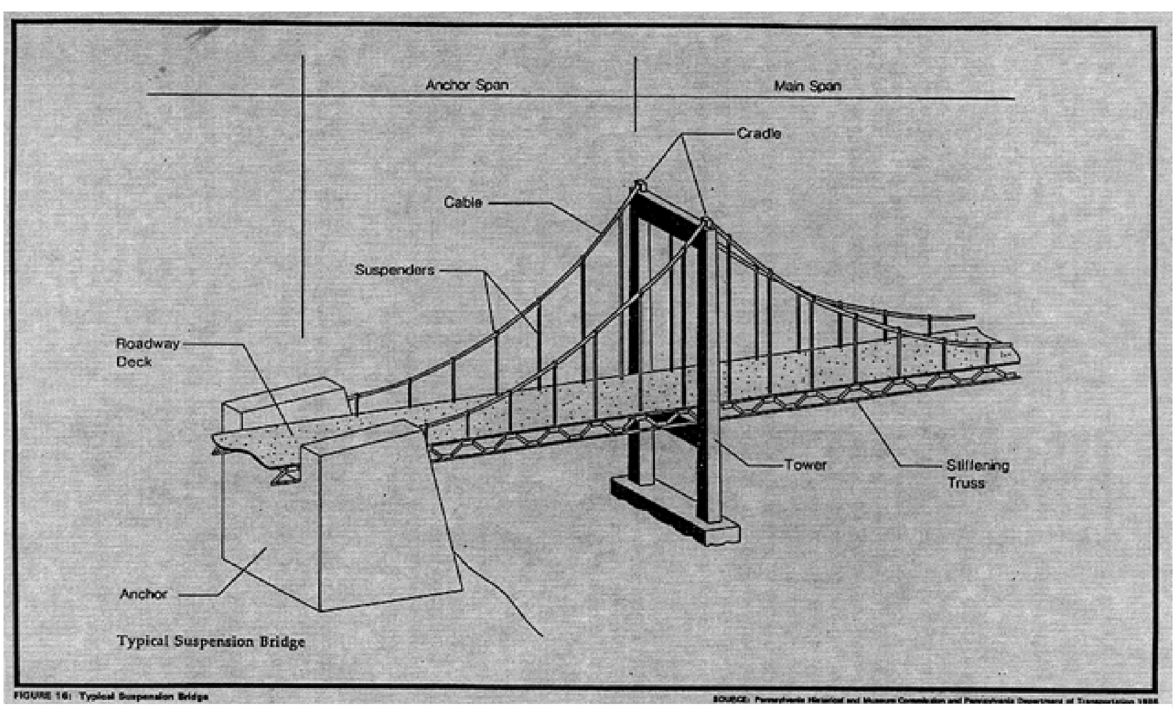
Steel I-beam – Steel I-beams are rolled steel sections up to 36 inches in depth that support the deck and carry the load to the bearings located on the supports. The I-beam can be encased in concrete.

Stringer – A beam aligned with the length of a span that usually extends between floor beams and assists in supporting the deck.

Substructure – The abutments at either end of the bridge and, if a bridge has more than one span, intermediate supports called piers or bents that support the superstructure of a bridge.

Superstructure – The portion of a bridge structure that carries the traffic load and passes that load to the substructure. INDOT defines the superstructure as the entire portion of a bridge above the abutment and pier seats, excluding the deck.

Suspension bridge – The suspension bridge uses towers to provide vertical support for a system of iron chains or wire cables, which suspend the deck of the bridge and are anchored in their extreme ends. The suspension bridge was especially designed to accommodate long spans. The decks were often stiffened by deck trusses to prevent collapse due to external forces induced by traffic and/or wind loads. In wire cable suspension bridges, the main cable runs from the anchorage at the abutments over the tops of the towers for the entire span length. Vertical cables hung from the main cable support the deck system.



Suspension bridge

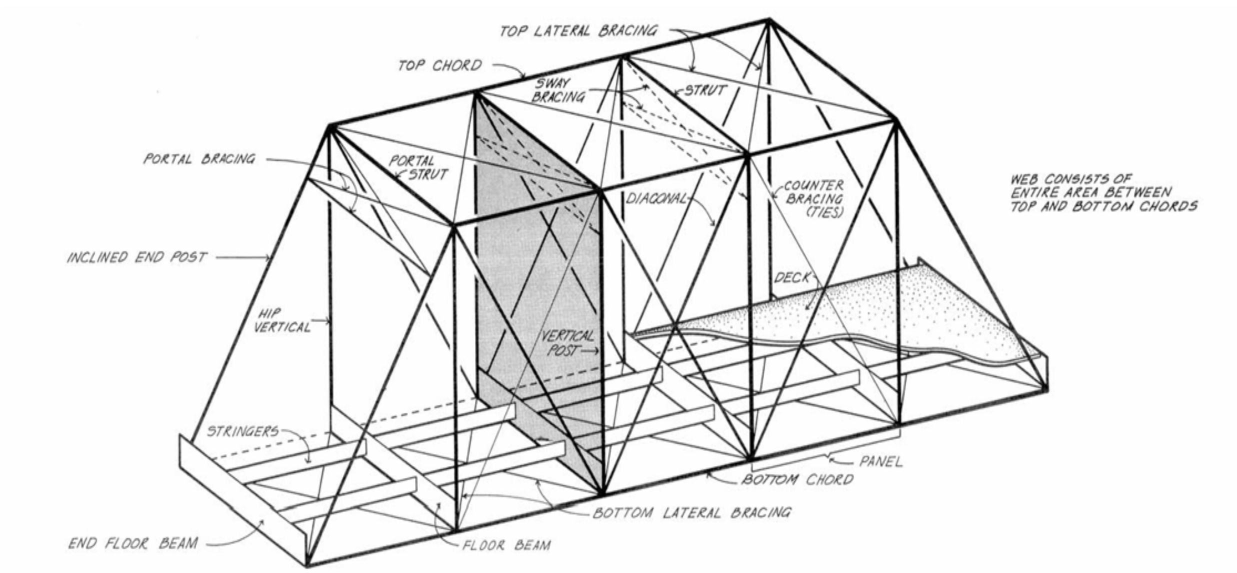
Swing bridge – A moveable bridge where the main span pivots horizontally 90 degrees on a central pier. This bridge type was constructed mostly during the 1890s-1920s and is one of the earliest moveable bridge types.

Tension – A type of stress tending to elongate a body. It tends to lengthen a member (the opposite of compression).

Through arch – A through arch has the roadway passing through the arch with the crown of the arch above the deck and the foundations of the arch below the deck suspended by hangers from the arch.

Through truss – A through truss is most commonly defined as a truss that features lateral bracing between the top chords over the deck. The roadway is located under and between the load-carrying members with traffic traveling through the truss. Also referred to as an overhead truss. See also deck truss and pony truss.

Truss – A structural form that is made of a web-like assembly of smaller members usually arranged in a triangular pattern. A truss bridge uses diagonal and vertical members to support the deck loads. The diagonal and vertical members are joined with plates and fasteners (pins, rivets, or bolts) to create several rigid triangular shapes. This configuration allows relatively light units to be created for large spans. There are three basic arrangements of trusses – pony, through, and deck – and a wide variety of subtypes.



Truss members

Underpass – A grade separation where the highway passes under an intersecting highway or railroad.

Unreinforced concrete – Before reinforcements were used, plain or massed concrete worked solely under compression and was only applicable to the arch form.

Viaduct – A long, multi-span bridge for carrying a road over a valley, another road, or railroad.

Welded connections – Introduced by 1930, welded connections are created by heating and melting two pieces of metal together to form a “bead” of molten steel. Used for trusses and beam/girder bridges.

Appendix B. Indiana National Bridge Inventory, Preliminary Analysis of Bridge Types

Indiana National Bridge Inventory (NBI), Preliminary Analysis of Bridge Types

This table is based on data provided by INDOT during June 2006 for state and county bridge inventory and inspection data. The data was consolidated to complete a preliminary analysis of select NBI data items to offer general characteristics of 6,333 bridges that appear to have been constructed through 1965. The table is organized by bridge construction material and follows the order of discussion presented in Section 3.

Bridges excluded from this analysis and table include railroad bridges, privately owned bridges, bridges for which INDOT does not have primary maintenance responsibility (including select border bridges and bridges maintained by other state and federal agencies), and bridges located on the Interstate Highway System. This is a preliminary analysis of initial sorts of these data. As further information is learned in subsequent steps of the project through bridge-specific research and field review, the actual number of bridges identified by type and their characteristics will be refined. Each bridge type is listed with its years in use, median span length, and longest span length.

Bridge Type	Percentage of Bridges Constructed through 1965	Years in Use[1]	Median Span Length (ft.)	Longest Main Span Length (ft.)
Timber				
Covered bridge	Less than 1% (57 examples)	Built consistently throughout the study period (1838-1922)	102	198
Timber girder or stringer	Less than 1% (18 examples)	1920 through 1960	81	40
Timber slab	Less than 1% (12 examples)	1920 through 1956	25	31
Timber trestle	Less than 1% (4 examples)	1912 through 1940	25	31
Stone				
Stone arch	Less than 1% (55 examples)	Built consistently throughout the study period (1875 to 1940)	22	80

[1] The database includes an anomaly regarding the year a structure was built – including a year built date and a year reconstructed date, if significant changes were made to a structure. In some cases the year reconstructed date may indicate that a new superstructure was placed on existing abutments with the year built referencing the original superstructure. However, the database does not provide an interpretation of the year reconstructed field. As a result, the years in use date range provided in the table may not accurately reflect the year the superstructure was built. For future phases of the project, the year that the superstructure was built will be used as the date of construction.

Bridge Type	Percentage of Bridges Constructed through 1965	Years in Use[1]	Median Span Length (ft.)	Longest Main Span Length (ft.)
Metal				
Bascule	Less than 1%	Only one example – built in 1932 and reconstructed in 1998	182	182
Metal arch	Less than 1% (22 examples)	1920s through study period	22	441
Metal truss	7%	Built consistently throughout the study period (1848 to 1965)	88	298
Steel beam or girder	25%	Built consistently throughout the subject period (1870 to 1965)	40	185
Steel railroad cars (converted for use as bridges)	Less than 1% (18 examples)	Built consistently throughout the subject period (1899 to 1958)	47	70
Concrete				
Concrete arch	11%	Built consistently throughout the study period (1899-1965)	50	190
Concrete beam or girder	11%	Built consistently throughout the study period (1896 -1965)	35	122
Concrete box girder	Less than 1% (4 examples)	1930s – through study period (1932 -1965)	28	35
Concrete channel beam	3%	Built consistently throughout the study period (1899 -1965)	29	40
Concrete rigid frame	Less than 1% (23 examples)	1930s through 1960s	21	60
Concrete slab	13%	1900 through 1965	24	101
Reinforced concrete girder (or T-beam)	Less than 1% (62 examples)	Built consistently throughout the study period (1905-1965)	32	95
Prestressed concrete box beam or girder	6% *	1950s through study period*	38	96

Bridge Type	Percentage of Bridges Constructed through 1965	Years in Use[1]	Median Span Length (ft.)	Longest Main Span Length (ft.)
Prestressed concrete I-beam or girder	Less than 1%*	1950s through study period*	60	118
Prestressed concrete slab	Less than 1% (1 example)	Post-1950**	58	58
Prestressed concrete t-beam	Less than 1% (1 example)	1959	40	40
Culverts				
Concrete culvert	4%	1902 through 1965	30	99
Stone culvert	Less than 1% (2 examples)	Examples date from 1840 and 1900	22	23t
Metal culvert	2%	1900 through 1965	13	47

*These figures eliminate bridges coded as prestressed concrete design with year constructed (NBI Item 27) prior to 1950, and a year reconstructed (NBI Item 106) after 1965. Since prestressed concrete was not used as a bridge-building material until 1949, these bridges are assumed to have a prestressed concrete superstructure that post dates 1966.

** This bridge has a year constructed of 1919 and a reconstruction date of 2004. Since prestressed concrete was not used as a bridge-building material until 1949, this bridge is assumed to have a prestressed concrete superstructure that post dates 1966.